MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

TECHNICAL REPORT RD-83-2

COMPUTER PROGRAM FOR ESTIMATING STABILITY DERIVATIVES OF
MISSILE CONFIGURATIONS - USERS MANUAL

George A. Sanders
W. D. Washington
Systems Simulation and Development
 Directorate
US Army Missile Laboratory

August 1982

U.S. ARMY MISSILE COMMAND
Redstone Arsenal, Alabama 35809

DTIC
ELECTE
JUN 15 1983
A

83 06 13 101

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER TR-RD-83-2	2. GOVT ACCESSION NO. AD-A129 501	3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)* COMPUTER PROGRAM FOR ESTIMATING STABILITY DERIVATIVES OF MISSILE CONFIGURATIONS - USERS MANUAL		5. TYPE OF REPORT & PERIOD COVERED TECHNICAL REPORT
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR*(s)* George A. Sanders W. D. Washington		8. CONTRACT OR GRANT NUMBER*(s)*
9. PERFORMING ORGANIZATION NAME AND ADDRESS Commander, US Army Missile Command ATTN: DRSMI-RD Redstone Arsenal, AL 35898		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS Commander, US Army Missile Command ATTN: DRSMI-RPT Redstone Arsenal, AL 35898		12. REPORT DATE Aug. 1982
		13. NUMBER OF PAGES
14. MONITORING AGENCY NAME & ADDRESS*(if different from Controlling Office)*		15. SECURITY CLASS. *(of this report)* UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
16. DISTRIBUTION STATEMENT *(of this Report)* Cleared for public release; distribution unlimited.		
17. DISTRIBUTION STATEMENT *(of the abstract entered in Block 20, if different from Report)*		
18. SUPPLEMENTARY NOTES		
19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)* computer program AERODSN MICOM Interdata 8/32 computer Mach numbers angles of attack		

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*
    This report is intended to be a users manual for a computer program called
AERODSN, which estimates the stability coefficients of typical missile con-
figurations with wings or tail fins or both. The Mach range is from zero to
approximately 4.0. The roll orientation is zero (plus configuration). Wings
and tails must be in line. Control deflections are allowed. A limited amount
of body alone experimental data is included (ogive cylinder or cone cylinder);
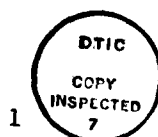however, body alone tables can be input if desired. A conical boattail segment

can be added. This program does not predict drag. Static stability and
damping derivatives at zero angle of attack are predicted.

CONTENTS

Accession For

GRA&I

TAB

announced

Justification

Distribution/

Availability Codes

Avail and/or

Special

Dist

A

DTIC
COPY
INSPECTED
7

1

1. INTRODUCTION

The purpose of this report is to provide a users manual and make comparative runs to verify a computer program called AERODSN. This report includes a step by step procedure for input and run instructions, a description of each output section and comparative plots to verify normal force and pitching moment coefficients. The program is a design tool for preliminary design phase of missile development programs. The current version is an update of AERODSN described in Reference 1. Changes in the program include referencing all coefficients to the reference area (input by the user), and changing the input format to free field read for convenience. The major portion of this program is concerned with the aerodynamics associated with adding wings and tails or both to a body of revolution. A limited amount of experimental body alone data is included for simple configurations (ogive cylinder or cone cylinder); however, body alone tabular data (CNA,Xcp) can be input. A conical boattail segment can be included if desired. Runs from AERODSN were compared with experimental data to establish a range of applicability. Data base configurations such as ADVINT, HIALFA, DCATFL and COPHED were used for comparison.

II. PROGRAM DESCRIPTION

The program was written to be used in preliminary design of typical missile shapes. Its primary function is to calculate the aerodynamics of wings or tails or both added to a cylindrical-shaped body using a combination of theoretical and imperical data. A limited amount of body alone data (cone cylinder and ogive cylinder) are included as an option; however, the body alone data can be input if desired. The roll orientation is assumed to be a plus configuration or zero roll. Wings and tails must be inline. Dynamic stability derivatives (damping) are calculated at zero angle of attack and zero control deflection. Angle of attack data is output corresponding to the values of alpha input. Table 1 summarizes the applicable ranges of independent variables. A description of each subroutine can be found in Reference 1. A listing of the program is presented in Appendix A.

III. INPUT

The following tables describe each record input. Table 2 is the general input format. Table 3 is a sample input file for a specific missile configuration.

IV. RUN INSTRUCTIONS

Two steps are required to run AERODSN on the MICOM Interdata 8/32 Computer. These steps are: (1) Develop and input file and, (2) Run the program using the CSS procedure AERODSN (already established on the system).

    A. STEP 1 – Referring to the Input section, develop an input file using the edit mode. Inputs are separated by blanks or commas (free field read). Save the file by typing "SAVE filename". Exit the edit mode by typing "END".

TABLE 1.   APPLICABLE RANGE OF INDEPENDENT VARIABLES

MACH NUMBER	0.0 TO 4.0
ANGLE OF ATTACK	0 TO 20 DEG.
ROLL ANGLE	0.0 DEG.
CONFIGURATIONS	BODY,BODY TAIL
	BODY WING,BODY WING TAIL
SWEEP ANGLE	NO FORWARD SWEPT WINGS.
FIN TAPER RATIO	0-1.
ASPECT RATIO	CONSISTANT WITH SLENDER BODY THEORY

TABLE 2.   GENERAL INPUT FORMAT AND DEFINITION OF INPUTS

ALL GEOMETERIC VARIABLES MUST HAVE THE SAME SYSTEM OF UNITS.

I.E., CALIBERS, INCHES, ETC. ALL ARE DIVIDED BY DREF WITHIN

THE PROGRAM. THE PROGRAM WORKS IN CALIBERS.

A CALIBER IS DEFINED AS 1 REFERENCE DIAMETER.

INPUT BODY CENTER OF PRESSURE (POSITIVE AFT OF NOSE) - (CAL)

PROGRAM USES BRITISH DATA SHEETS FOR BASIC WING LIFT AND XCP.

PROGRAM USES SLENDER BODY THEORY (NACA 1307) FOR WING-BODY

AND WING-TAIL INTERFERENCE.

....

ALL INPUTS ARE FREE FIELD. INPUTS CAN BE SEPARATED BY A COMMA,

ONE OR MORE BLANKS, OR BY A SLASH (/).

ALL VARIABLES IN AN INPUT LINE MUST HAVE A VALUE TO READ,

I.E., 0. FREE FIELD READ WILL NOT INTERPRET BLANKS AS ZERO'S.

.... INPUT 1

TITLE CARD (1-80 CHARACTERS)

.... INPUT 2

NWPOS	=	1	INPUT XWING AS STATION OF WING LEADING EDGE
"	=	2	PROGRAM WILL MOVE WING 1/4 CHORD TO WING HINGE LINE
"	=	3	PROGRAM WILL MOVE WING 1/2 CHORD TO WING HINGE LINE
"	=	4	INPUT XWING AS STATION OF WING TRAILING EDGE
NTPOS	=	1	INPUT XTAIL AS STATION OF TAIL LEADING EDGE
"	=	2	PROGRAM WILL MOVE TAIL 1/4 CHORD TO TAIL HINGE LINE
"	=	3	PROGRAM WILL MOVE TAIL 1/2 CHORD TO TAIL HINGE LINE
"	=	4	INPUT XTAIL AS STATION OF TAIL TRAILING EDGE

5

TABLE 2. GENERAL INPUT FORMAT AND DEFINITION OF INPUTS (Cont'd).

MCDVT   = 1   NO EFFECT.

"   = 2   USE NACA REPT. 1253 (MCDEVITT) FOR FIN ALONE CLA.

               GOOD FOR RECTANGULAR FINS ONLY.

               GOOD FOR MACH NUMBERS BELOW 1.1 ONLY.

NOUT   = 1   TRIM OUTPUT ONLY.

         = 2   ALPHA OUTPUT ONLY.

         = 3   TRIM AND ALPHA OUTPUT.

NRUN   =   INITIAL RUN NUMBER. - 1 TO 4 DIGITS.

NDBASE   = 1   NO EFFECT.

         = 2   OUTPUT DATA BASE FILE.

.... INPUT 3

NOSE   = 1   OGIVE NOSE

"   = 2   CONICAL NOSE

XLN   =   NOSE LENGTH

XL   =   TOTAL LENGTH

.... INPUT 4

RBW   = RADIUS OF BODY AT WING

RBT   = RADIUS OF BODY AT TAIL

DREF   = REFERENCE LENGTH

AREF   = REFERENCE AREA

DREFFT   = REFERENCE LENGTH - FT.

AREFFT   = REFERENCE AREA IN SQ. FT.

YIY   = TRANSVERSE MOMENT OF INERTIA - SLUG-FT2.

6

TABLE 2. GENERAL INPUT FORMAT AND DEFINITION OF INPUTS (Cont'd).

.... INPUT 5

NBODY   = NUMBER OF POINTS FOR BODY ALONE CNACY AND XCPCY

          (IF NBODY=0, OMIT IMPUTS 6. PROGRAM WILL COMPUTE SLOPE DATA.)

.... INPUTS 6

TMACH   = TABLE OF MACH NUMBERS FOR CNACY AND XCPCY

TCNACY   = TABLE OF BODY ALONE NORMAL FORCE COEFF SLOPES (BASED ON

          BODY CROSS SECTIONAL REFERENCE AREA) - 1/RAD

TXCPCY   = TABLE OF BODY ALONE CENTER OF PRESSURE - CAL FROM NOSE

.... INPUT 7

NBTL=0   PROGRAM WILL NOT ADD BOATTAIL CNA AND XCP.

"   =1   PROGRAM USES BOATTAL CARDS TO CALCULATE BOATTAIL EFECTS

DBOD = DIAMETER RATIO (BOATTAIL/CYLINDER)

XLBOD = RATIO (BOATTAIL LENGTH/CYLINDER DIAMETER)

.... INPUT 8

NMF   = NUMBER OF POINTS FOR XCG VS MACH NUMBER

.... INPUTS 9

TMF   = TABLE OF MACH NUMBERS FOR XCG

TXCG   = TABLE OF CENTER OF GRAVITY - CALIBERS FROM NOSE.

TWEIGH   = TABLE OF WEIGHT - LBS.

.... INPUT 10

TABLE 2. GENERAL INPUT FORMAT AND DEFINITION OF INPUTS (Concluded).

NFMA   = NUMBER OF FREE STREAM MACH NUMBERS

.... INPUTS 11

TFMA   = TABLE OF FREE STREAM MACH NUMBERS

TALT   = ALTITUDE FOR EACH MACH NO. - FT ABOVE SEA LEVEL

TRE   = REYNOLDS NUMBER FOR EACH MACH NO. - MILLIONS/FT.

         NOTE: PROGRAM MULTIPLIES TRE BY 1 MILLION TO GET RE.

.... INPUTS 12-26

TBOW   = TABLE OF WING EXPOSED SEMI-SPANS(LOAD 0. IF NO WING)

TCRW   = TABLE OF WING ROOT CHORDS

TTRW   = TABLE OF WING TAPER RATIOS(CT/CR)

TSWTEW   = TABLE OF WING TRAILING EDGE SWEEP ANGLES(DEG)

TXWING   = TABLE OF WING STATIONS (MEASURED FROM NOSE) (SEE NWPOS)

THINGW   = TABLE OF WING HINGE LINES

TBOT   = TABLE OF TAIL EXPOSED SEMI-SPANS(LOAD 0. IF NO TAIL)

TCRT   = TABLE OF TAIL ROOT CHORDS

TTRT   = TABLE OF TAIL TAPER RATIOS (CT/CR)

TSWTET   = TABLE OF TAIL TRAILING EDGE SWEEP ANGLES (DEG)

TXTAIL   = TABLE OF TAIL POSITIONS (MEASURED FROM NOSE)

THINGT   = TABLE OF TAIL HINGE LINES

"   = 0. (PROGRAM SETS HINGT=1/4 MEAN AERODYNAMIC CHORD)

TDELT   = TABLE OF TAIL DEFLECTIONS - DEG.

TDELW   = TABLE OF WING DEFLECTIONS - DEG.

TALP   = TABLE OF ANGLES OF ATTACK - DEG.

8

TABLE 3.   SAMPLE INPUT FILE FOR AERODSN

```
 1        SAMPLE INPUT FILE: BODY-WING-TAIL.
 2.       1 1 1 3 1 1
 3.       1 7.470 47.000
 4.       3. 3. 6.0 28.27 .50 .1903 1
 5.       6
 6.       .5 3.197 3.014
 7.       .8 3.059 3.154
 8.       .95 3.248 3.317
 9.       1.2 3.151 2.431
10.       1.5 3.145 1.978
11.       1.8 3.008 1.742
12.       0 1.0 0.0
13.       2
14.       0.0 4.544 1.0
15.       1.0 4.544 1.0
16.       2
17.       .5 0.0 3.592
18.       1.8 0.0 12.933
19.       7.149
20.       3.051
21.       1.0
22.       20.0
23.       32.32
24.       0.0
25.       5.974
26.       3.051
27.       1.0
28.       20.0
29.       41.226
30.       42.582
31.       0.
32.       0.0
33.       -5 -2 0.0 2 4 6 8 10 12 14 16 18 20
```

B.   STEP 2 - To run the program typ, "AERODSN" and press "RETURN".
         Wait for instructions to appear and enter the name of
         the data file. When the program has finished running
         an "*" will appear on the screen.

V.   OUTPUT

The output consists of five major groups:

- GEOMETRIC VARIABLES

- FLIGHT CONDITIONS

- ZERO ANGLE OF ATTACK DATA (SLOPES)

- TRIM POINT

- ANGLE OF ATTACK SWEEP

Presented in Table 4 are definitions of each output variable calculated
within each output group. Table 5 illustrates a sample output.

    The group GEOMETRIC VARIABLES is divided into three components which
are body, wing and tail. The corresponding geometric values are listed in
column form with the appropriate symbol and definition. Printed under
FLIGHT CONDITIONS are Mach number, center of gravity location (calibers
from the nose), altitude (ASL) in feet and Reynolds number (per ft.). These
values are taken directly from the input file. The ZERO ANGLE OF ATTACK
DATA (SLOPES) group is divided into body, wing, tail and total configura-
tion values. Each aerodynamic coefficient slope is evaluated at zero angle
of attack and is listed in column form corresponding to the missile component.
Aerodynamic coefficients are calculated for individual angles of attack in
the ANGLE OF ATTACK SWEEP group.

VI.   PROGRAM VALIDATION

    Comparisons are made to establish the range of validity. Configura-
tions taken from the AERODYNAMIC DATA BASE such as ADVINT, HIALFA, DCATFL,
and COPHED were used. Normal force and pitching moment coefficients were
generated by AERODSN and plotted against wind tunnel data for comparison.

    Detailed geometric description of each missile configuration tested
is included with the plots. The Mach numbers range from 0.2 to 4.0.
Angle of attack ranges from -5 to 25 degrees. Angles of attack greater
than 25 degrees are included in this report; however, user discretion is
advised. Missile configurations include body, body-tail, body-wing and
body-wing-tail.

    Figures 1 and 2 describe the geometry of ADVINT. Figures 3-26 show
comparison between ADVINT wind tunnel data and AERODSN. Normal force and
pitching moment coefficients are shown at Mach numbers of 1.95, 3.01 and
4.02. Body, body-tail, body-wing and body-wing-tail configurations are
compared. Run numbers beginning with A are ADVINT wind tunnel data and
runs beginning with G are AERODSN runs.

10

Figure 1. Body-tail details.
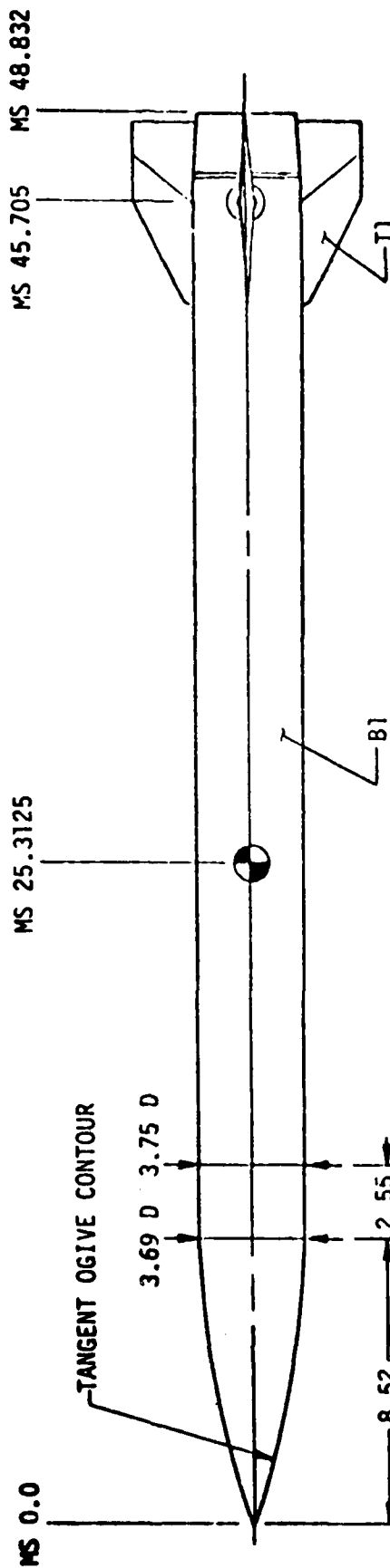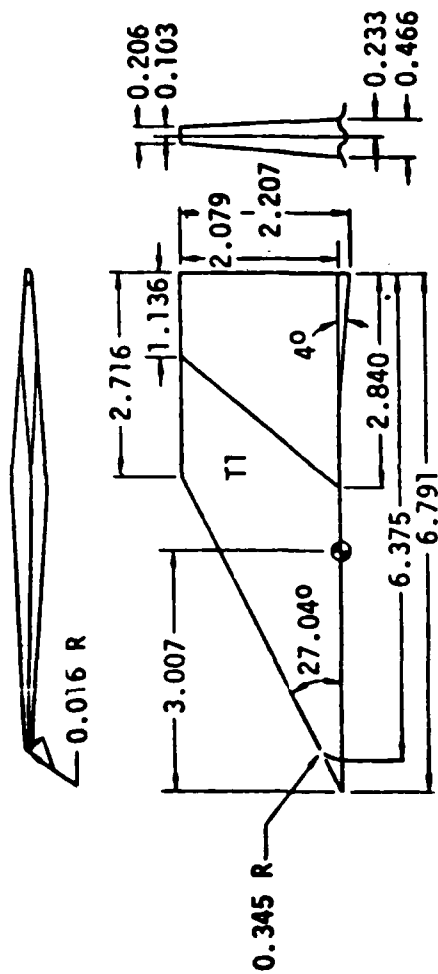
⊕ MOMENT REFERENCE POINT

ALL DIMENSIONS IN INCHES UNLESS OTHERWISE STATED
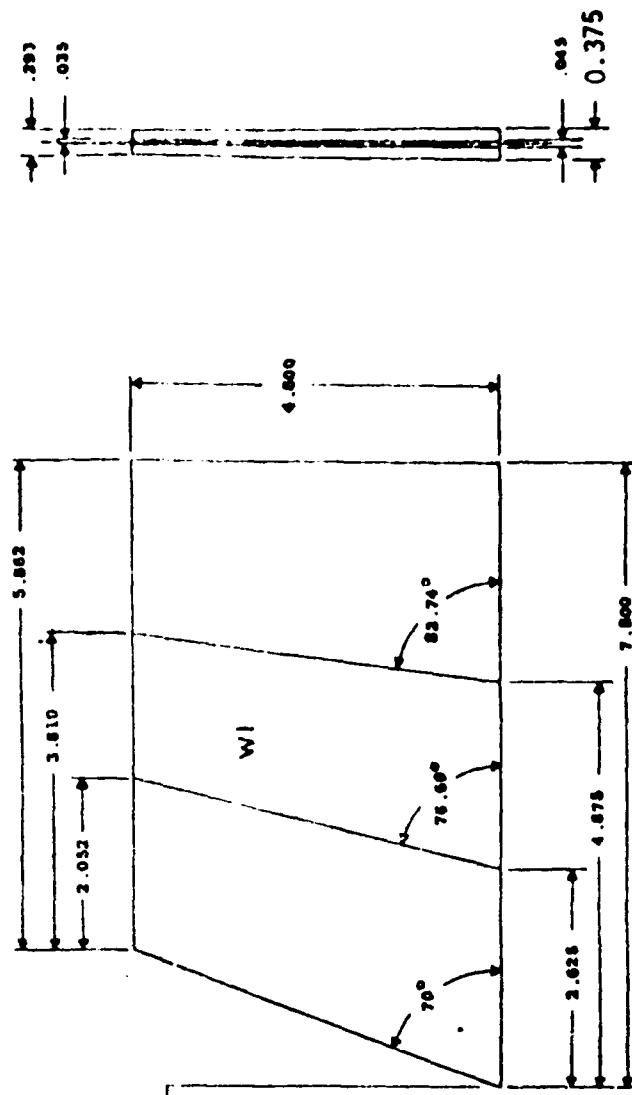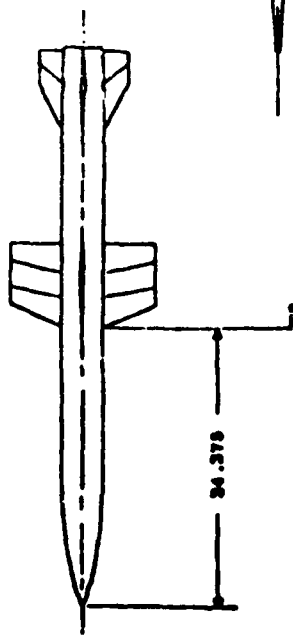
ALL DIMENSIONS IN INCHES UNLESS OTHERWISE STATED

SOURCE: Ref. 1

Figure 2. Straight wing (W1) details.

12

TABLE 4. DEFINITION OF OUTPUT

FLIGHT CONDITIONS

FMACH   FREE STREAM MACH NUMBER.

XCG   LOCATION OF CENTER OF GRAVITY (CALIBERS FROM NOSE).

WEIGHT   WEIGHT (LBS.).

ALT   ALTITUDE ABOVE SEALEVEL (FT.).

RE   REYNOLDS NUMBER X 10E6. (PER FT)

ZERO ANGLE OF ATTACK DATA (SLOPES)

BKUP   UPWASH; RATIO OF LIFT ON WINGS IN PRESENCE OF BODY TO LIFT

OF WING ALONE.

BKCO   CARRYOVER; RATIO OF LIFT ON BODY DUE TO WING TO LIFT OF

WING ALONE.

CLA   LIFT COEFFICIENT OF TAIL OR WING, BASED ON RESPECTIVE FIN AREAS.

(1/RAD).

CPF   CENTER OF PRESSURE OF WING OR TAIL MEASURED FROM ROOT

CHORD LEADING EDGE.

CNA   LIFT COEFFICIENT SLOPE OF COMPONENTS BASED ON AREF (1/RAD).

XCP   COMPONENT CENTER OF PRESSURE DIVIDED BY DREF.

MEASURED FROM NOSE.

CMACG   PITCHING MOMENT COEFFICIENT ABOUT CG BASED ON AREF AND

DREF.

CMQ   PITCH DAMPING COEFFICIENT SLOPE (ABOUT C.G.) DUE TO PITCH RATE, BASED

ON AREF AND DREF (1/RAD).

13

TABLE 4. DEFINITION OF OUTPUT (Cont'd)

CLP ROLL DAMPING COEFFICIENT SLOPE BASED ON AREF AND DREF.

    (1/RAD).

CLD ROLL MOMENT COEFFICIENT SLOPE (4 FINS OR 4 WINGS DEFLECTED),

    BASED ON AREF AND DREF (1/RAD).

CHA HINGE MOMENT COEFFICIENT SLOPE DUE TO ANGLE OF ATTACK,

    BASED ON AREF AND DREF (1/RAD).

CHD HINGE MOMENT COEFFICIENT SLOPE DUE TO CONTROL DEFLECTION,

    (FOR ALL MOVEABLE FINS),BASED ON AREF AND DREF (1/RAD).

CND NORMAL FORCE COEFFICIENT SLOPE DUE TO CONTROL DEFLECTION,

    BASED ON AREF (1/RAD).

CMDCG PITCHING MOMENT COEFFICIENT SLOPE ABOUT CG DUE TO

    CONTROL DEFLECTIONS (1/RAD).

SIGMA PITCH OSCILLATION NATURAL FREQUENCY (CYCLES/SEC).

TRIM POINT

ALPHA TRIM ANGLE OF ATTACK (DEG).

DELW WING DEFLECTION (DEG).

DELT TAIL DEFLECTION (DEG).

CN   TOTAL NORMAL FORCE COEFFICIENT (NF/Q AREF).

XCP LOCATION OF CENTER OF PRESSURE (FROM NOSE) XCP/DREF.

CMCG TOTAL PITCHING MOMENT COEFFICIENT ABOUT C.G. (PM/Q*AREF*DREF)

HMW HINGE MOMENT COEFFICIENT OF WING HMW/(Q*AREF*DREF).

HMT HINGE MOMENT COEFFICIENT OF TAIL HMT(/Q*AREF*DREF).

GLOAD **LATERAL MANEUVERABILITY (G'S)**

TABLE 4. DEFINITION OF OUTPUT (Concluded)

ANGLE OF ATTACK SWEEP

ALPHA   ANGLE OF ATTACK (DEG).

CN   TOTAL NORMAL FORCE COEFFICIENT NF/(Q*AREF).

XCP   LOCATION OF XCP (FORM NOSE) XCP/DREF

CMCG   TOTAL PITCHING MOMENT COEFFICIENT ABOUT C.G. PM/(Q*AREF*DREF)

CHW   HINGE MOMENT COEFFICIENT OF WING HMW/(Q*AREF*DREF).

CHT   HINGE MOMENT COEFFICIENT OF TAIL HMT/(Q*AREF*DREF).

CNB   BODY NORMAL FORCE COEFFICIENT NFB/(Q*AREF)

XCPB   LOCATION OF BODY XCP (FROM NOSE,XCPB/DREF).

CNW   NORMAL FORCE COEFFICIENT OF WING PLUS-BODY INTERFERENCE

          NFW/(Q*AREF).

XCPW   LOCATION OF WING XCP (FROM NOSE) XCPW/DREF.

CNT   NORMAL FORCE COEFFICIENT OF TAIL PLUS BODY TAIL INTERFERENCE

          NFT/(Q*DREF).

XCPT   LOCATION OF TAIL XCP (FROM NOSE) XCPT/DREF.

CNTV   NORMAL FORCE COEFFICIENT ON TAIL DUE TO WING VORTICES.

15

Figure 27 describes the Copperhead geometry. Figures 28-33 show normal force and pitching moment coefficient generated by AERODSN compared to that of Copperhead wind tunnel data. The Mach numbers tested are 0.5, 0.8 and 0.95 for the body-wing-tail configuration. Runs beginning with C are Copperhead wind tunnel data and runs beginning with T are AERODSN runs.

Figures 34-36 describe the geometry of the missile shape used for high angle of attack comparison. Nose 1, afterbody 1 and tail 11 were used. Alpha ranges from 25-45 degrees at Mach numbers of 2.0, 2.5 and 3.01. Runs beginning with "B" are HIALFA wind tunnel data and runs beginning with "O" are AERODSN runs. Figures 37-42 show normal force and pitching moment coefficient comparison.

Figures 43-44 describe the geometry for the body tail configuration used in this comparison. Figures 46-56 show normal force and pitching moment comparison at Mach numbers of 0.2 to 1.0. Angle of attack ranges from -6.0 to 6.0. Runs beginning with "A" are DCATFL wind tunnel data and runs beginning with "E" are AERODSN runs.

VII. SUMMARY AND CONCLUSIONS

The preliminary design computer program "AERODSN" has been evaluated for accuracy and range of applicability. A description of the inputs and outputs, as well as run instructions for running the program on MICOM's Interdata 8/32 computer, is included. "AERODSN" was tested at Mach numbers from 0.0 to 4.0. All configurations were tested with an angle of attack range from 0.0 to 20.0 degrees with the exception of one tested from 25.0 to 45.0 degrees. Roll orientations are zero for all cases. Body, body-wing, body-tail and body-wing-tail configurations were tested through the alpha and Mach ranges indicated based on the comparative analysis. The following conclusions are drawn:

A. The applicable Mach range is from 0 to 4.

B. In general, good results were obtained in CN and CM at angles of attack up to 20 deg alpha. In some cases, where configurations depart from the missile shapes applicable for this program, comparisons are not good for angles of attack greater than 5 deg.

C. "AERODSN" is applicable for configurations with roll orientations of zero only.

D. "AERODSN" is an acceptable preliminary design tool for obtaining a quick aerodynamic profile for missile shapes described in this report.

REFERENCES

1. Washington, William D., _Computer Program for Estimating Stability Derivatives of Missile Configurations_, US Army Missile Command, Redstone Arsenal, Alabama, 1976 Technical Report RD-76-25.

2. Royal Aeronautical Society, "Wings," _Aerodynamic Data Sheets_, Vol. 11, S.01.03.03, S.01.03.06, and S.08.01.02, May 1954.

3. Gafarian, A.F., and Phillips, W.L., _The Supersonic Lift and Centers of Pressure of Rectangular and Clipped Delta Fins in Combination with Long Cylindrical Bodies_, US Naval Ordnance Test Station, China Lake, California, 1963, Report No. TM-966.

4. McDevitt, John B., _A Correlation by Means of Transonic Similarity Rules of Experimentally Determined Characteristics of a Series of Symmetrical and Cambered Wings of Rectangular Plan Form_, National Advisory Committee for Aeronautics, Washington, D.C., 1955, NACA Report 1253.

5. Pitts, William C., Nielson, Jack N., and Dattari, George E., _Lift and Center of Pressure of Wing-Body-Tail Combinations at Subsonic Transonic, and Supersonic Speeds_, National Advisory committee for Aeronautics, Washington, D.C., 1959, NACA Report 1307.

6. Adams, Gaynor J. and Dugan, Duane W., _Theoretical Damping in Roll and Rolling Moment Due to Differential Wing Incidence for Slender Cruciform Wings and Wing-Body Combinations_, National Advisory Committee for Aeronautics, Washington, D.C., 1950 NACA Report 1088.

7. Spring, Donald J., _The Effect of Nose Shape and Afterbody Length on the Normal Force and Neutral Point Location of Axisymmetric Bodies at Mach Numbers From 0.8 to 4.5_, US Army Missile Command, Redstone Arsenal, Alabama, 1964, Report No. RF-TR-64-13.

8. Washington, William D. and Pettis, Wiley, Jr., _Boattail Effects on Static Stability at Small Angles of Attack_, US Army Missile Command, Redstone Arsenal, Alabama, 1968, Report No. RD-TM-68-5.

Figure 3. Body alone normal foile vs angle of attack at M = 1.95.

18

Figure 4. Body alone pitching moment vs angle of attack at M = 1.95.

19

Figure 5. Body alone normal toile vs angle of attack at M = 3.01.

20

Figure 6. Body alone pitching moment vs angle of attack at M = 3.01.

Figure 7. Body alone normal voile vs angle of attack at M = 4.02.

22

Figure 8. Body alone pitching moment vs angle of attack at M = 4.02.

SYM	RUN	CONFIGURATION	RUN	MACH	RN
o	G	4 BIT1	4.00	1.95	2.49
+	A	4 BIT1	4.00	1.95	2.50

CNP

5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0

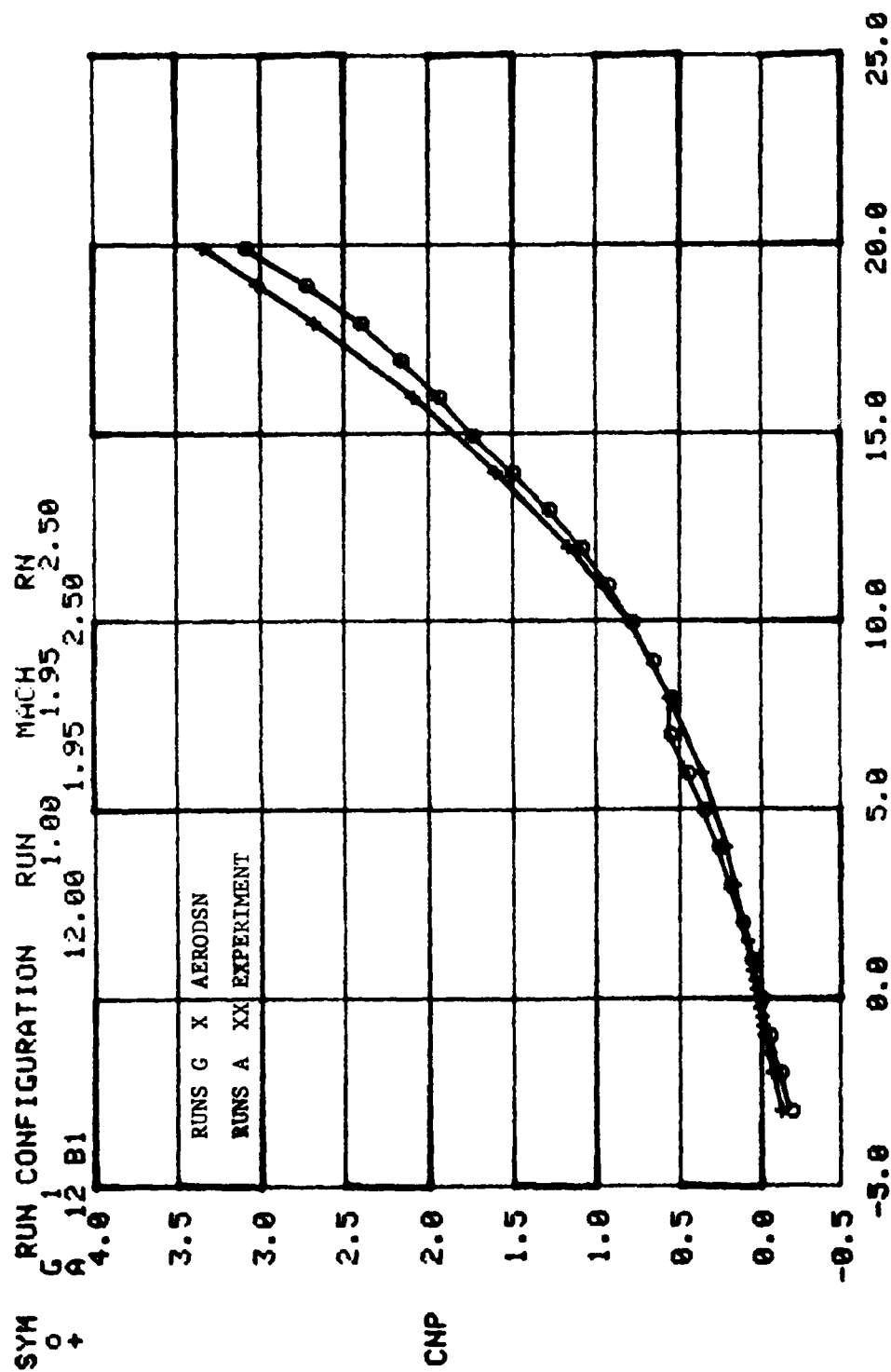-5.0 0.0 5.0 10.0 15.0 20.0 25.0

TOTAL ANGLE OF ATTACK,ALPP,DEG
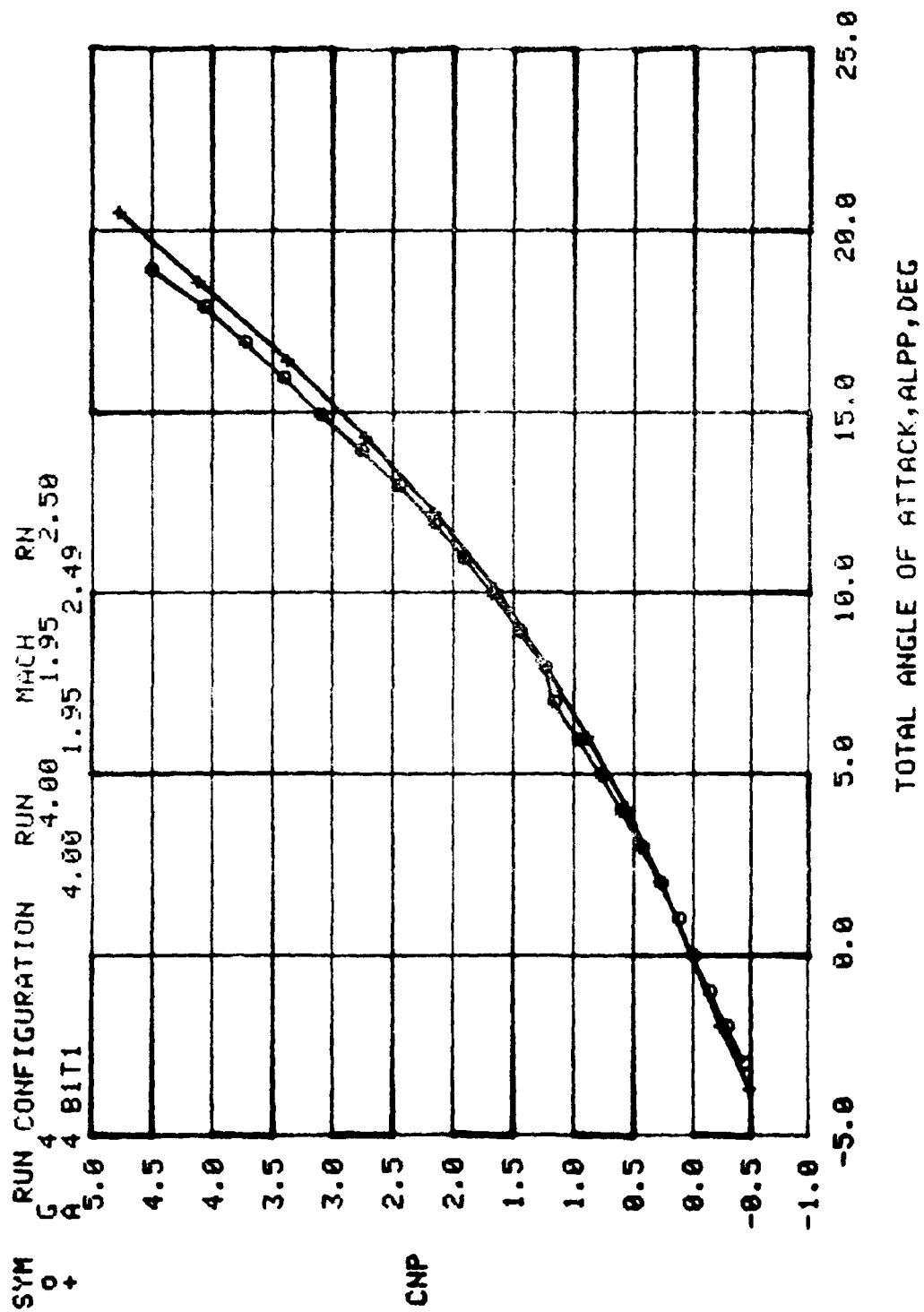
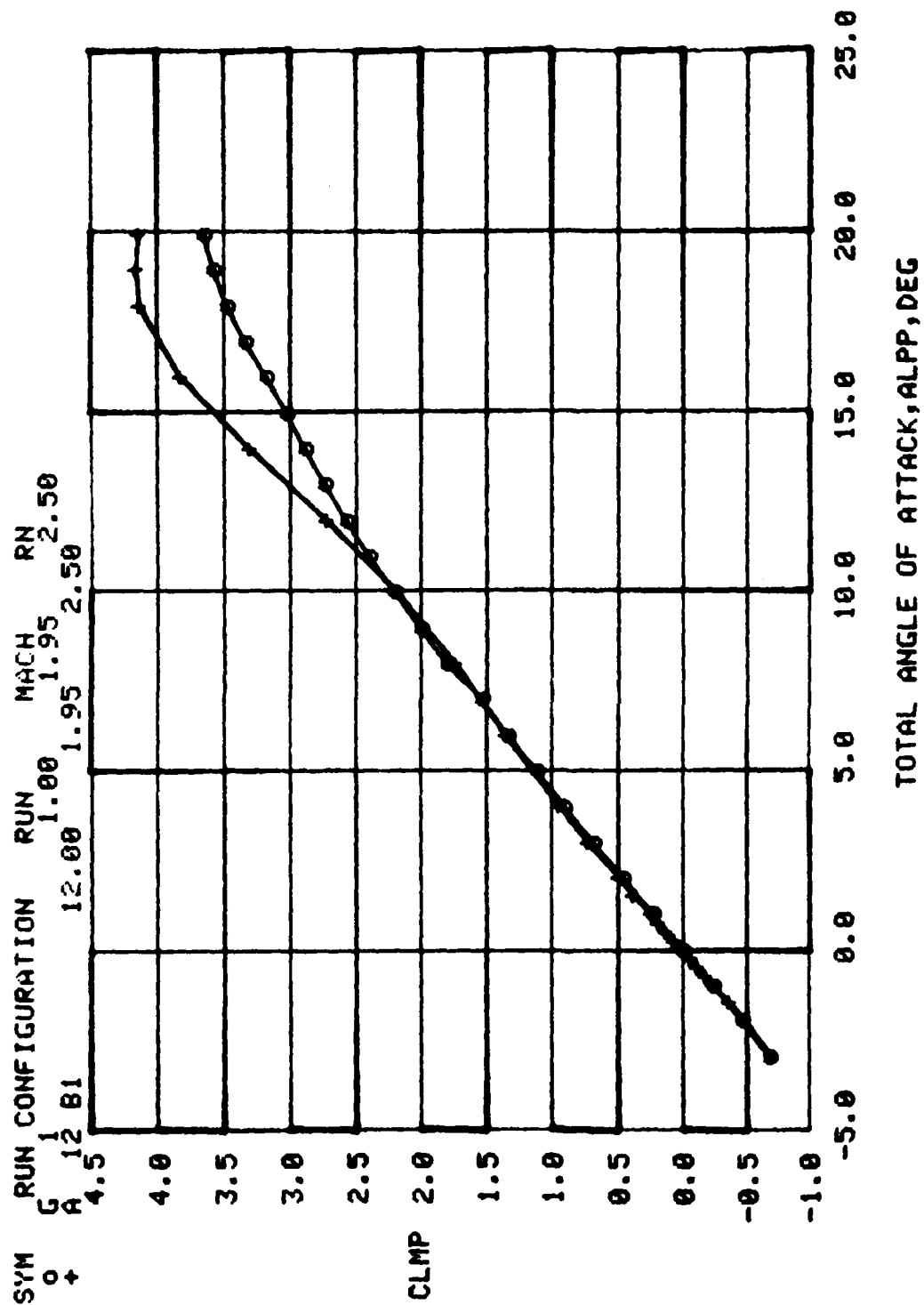Figure 9. Body tail normal force vs angle of attack at M = 1.95.
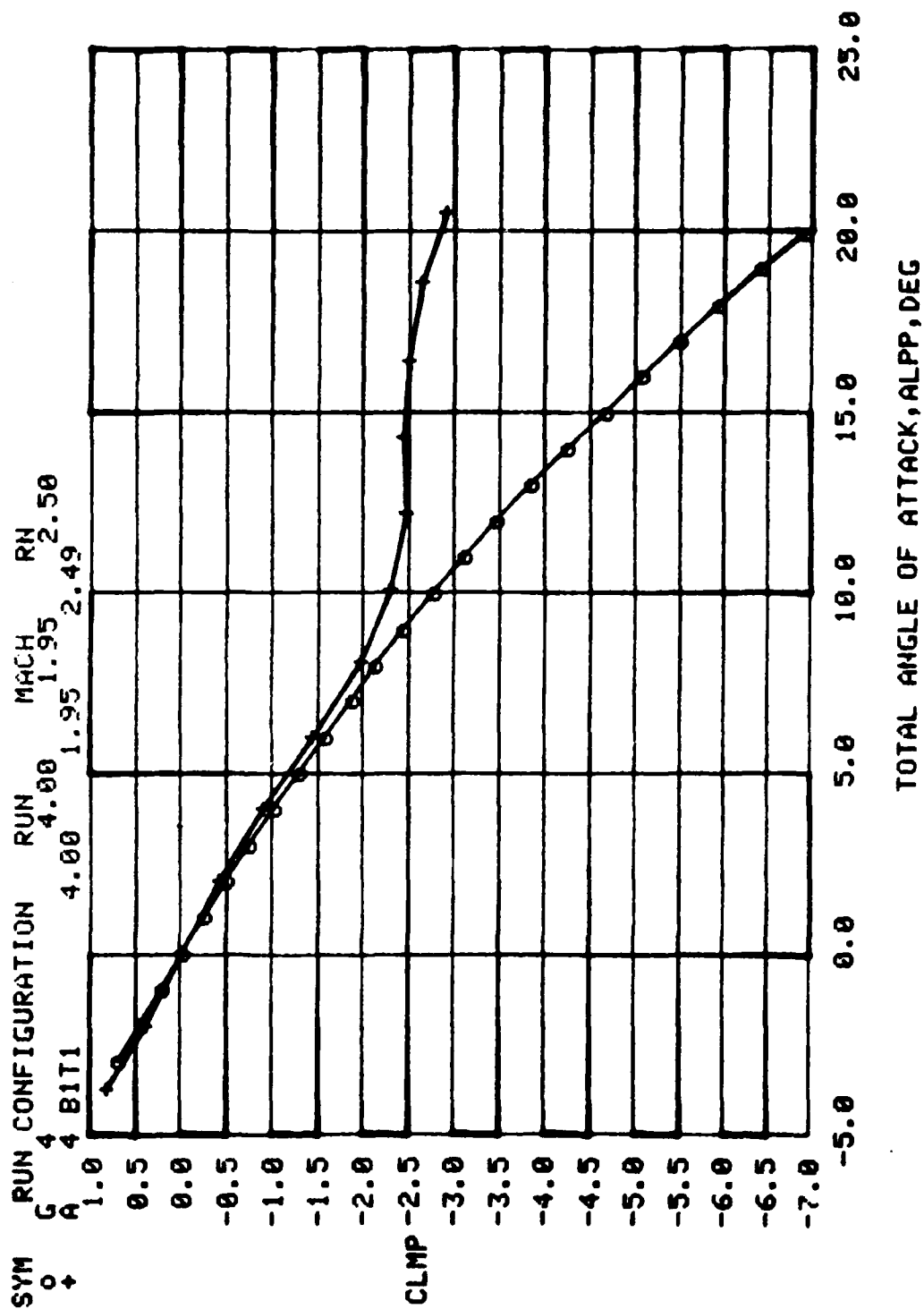
Figure 10. Body tail pitching moment vs angle of attack at M = 1.95.
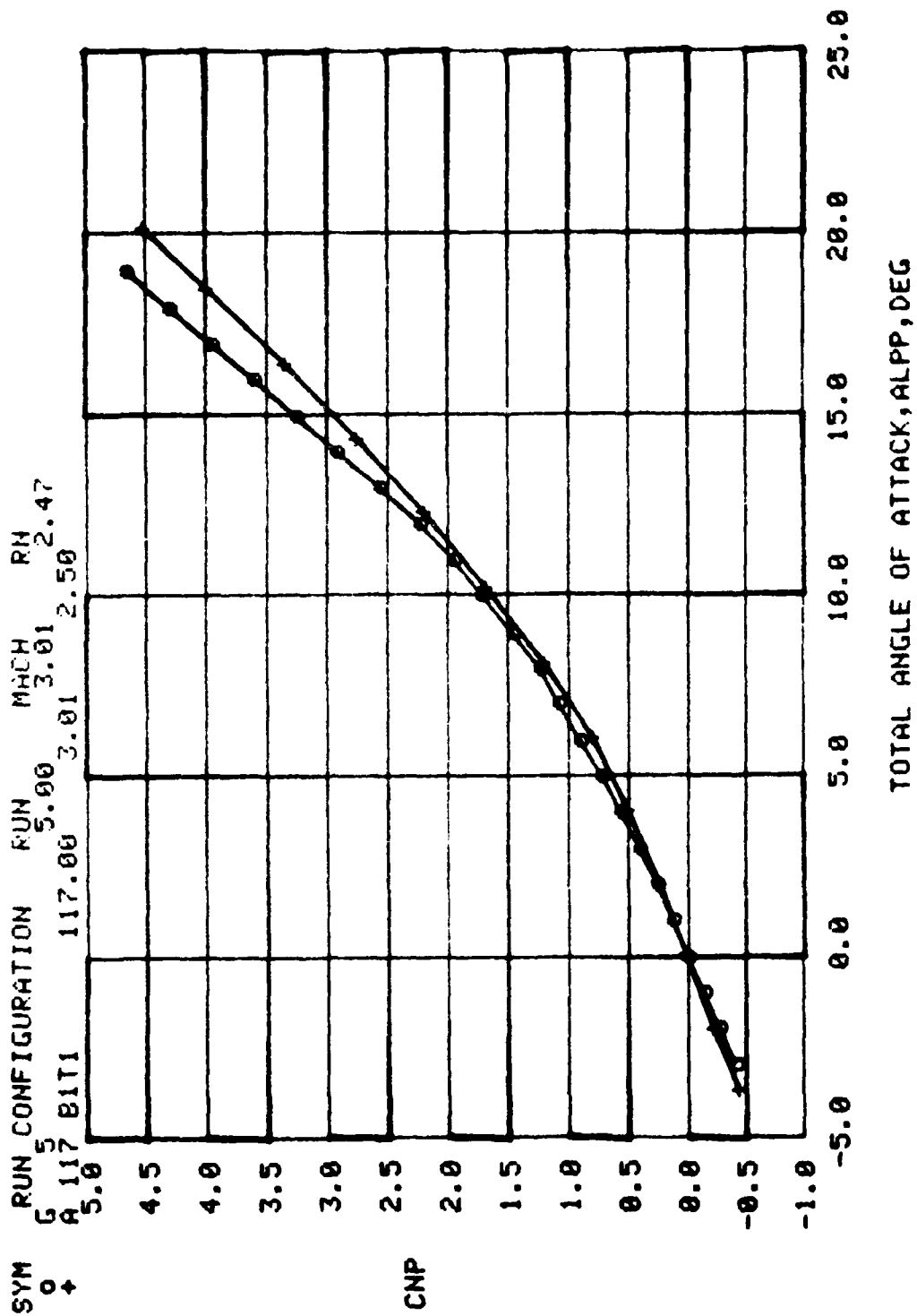
Figure 11. Body tail normal force vs angle of attack at M = 3.01.
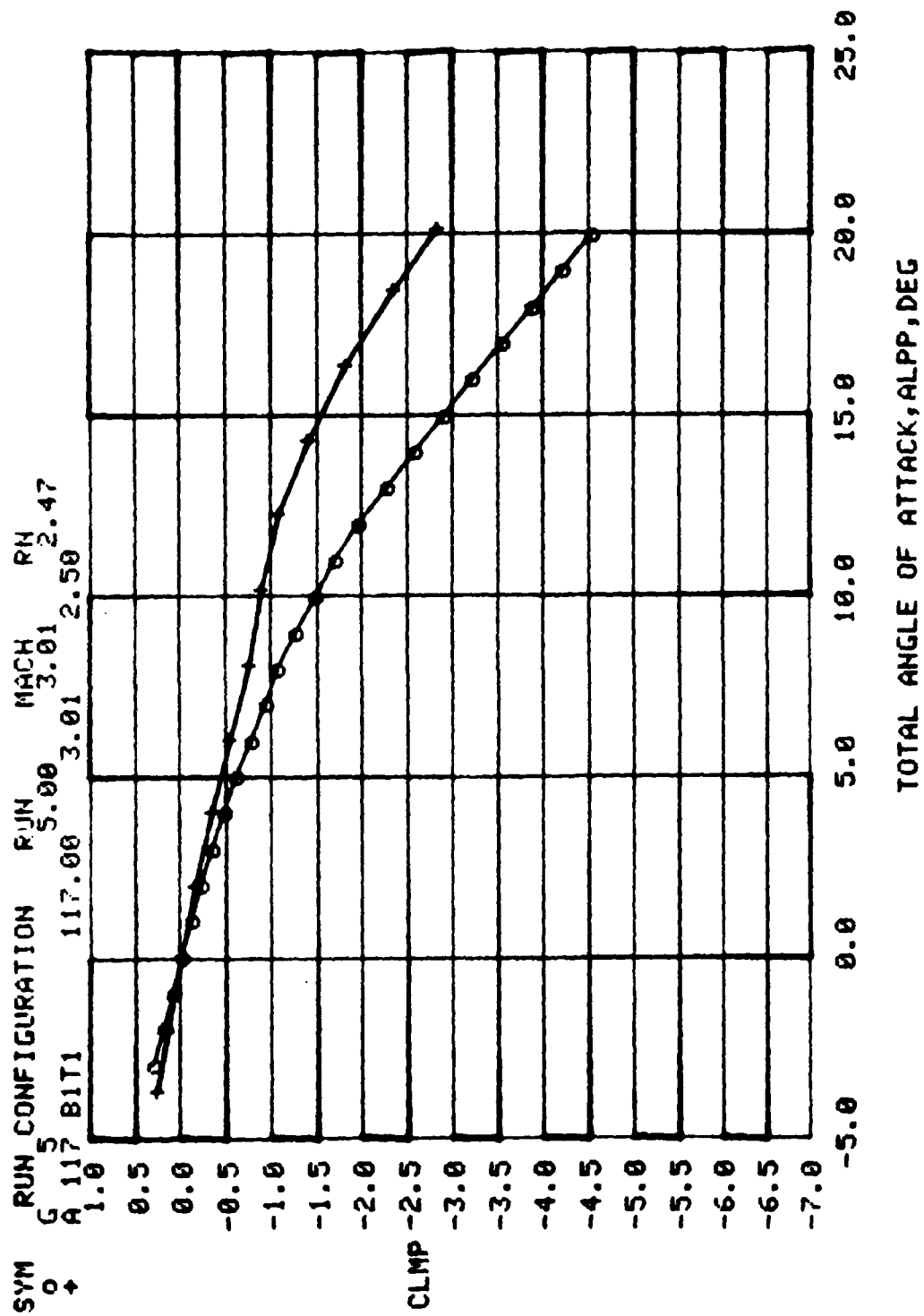
Figure 12. Body tail pitching moment vs angle of attack at M = 3.01.
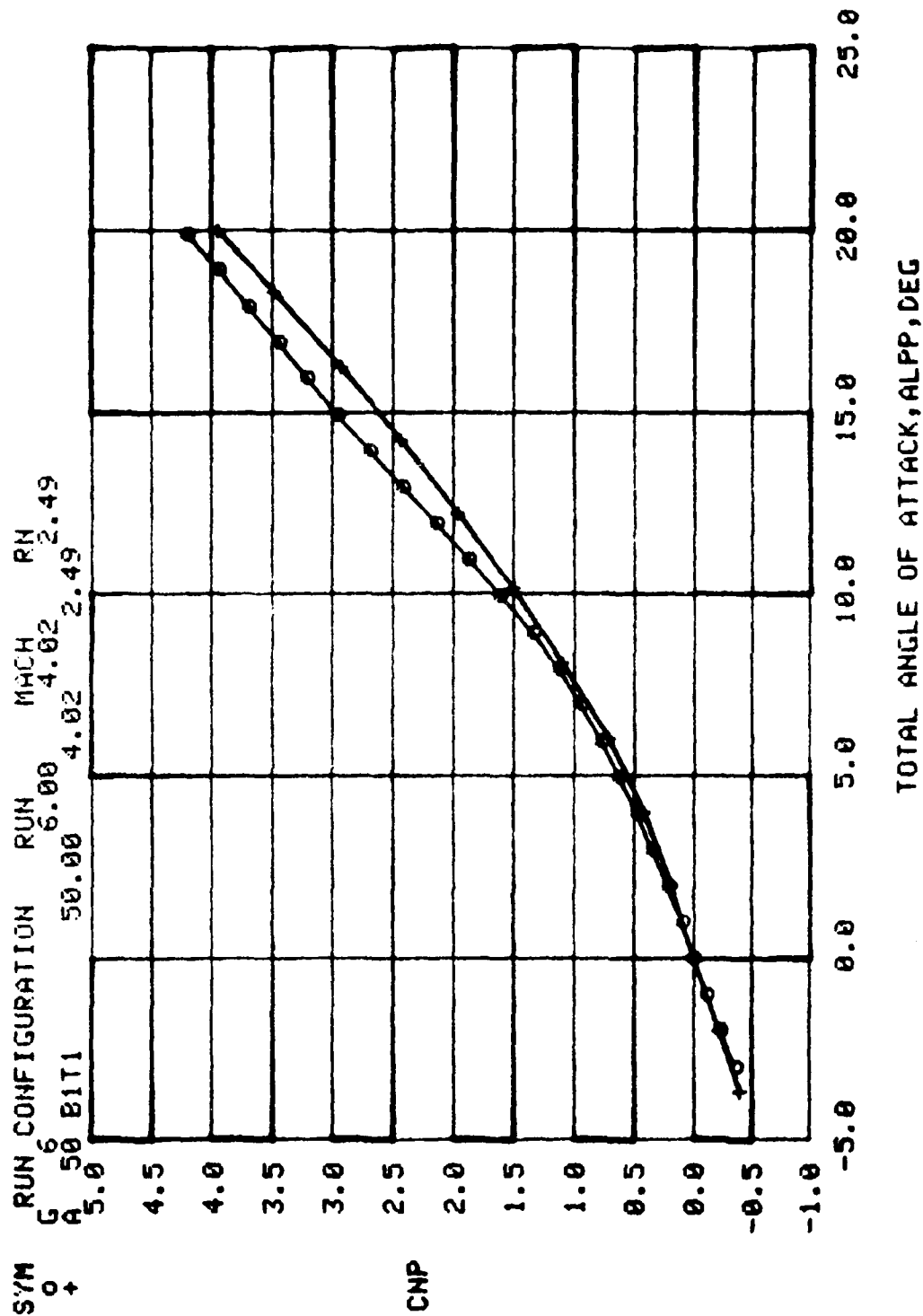
Figure 13. Body tail normal force vs angle of attack at M = 4.02.
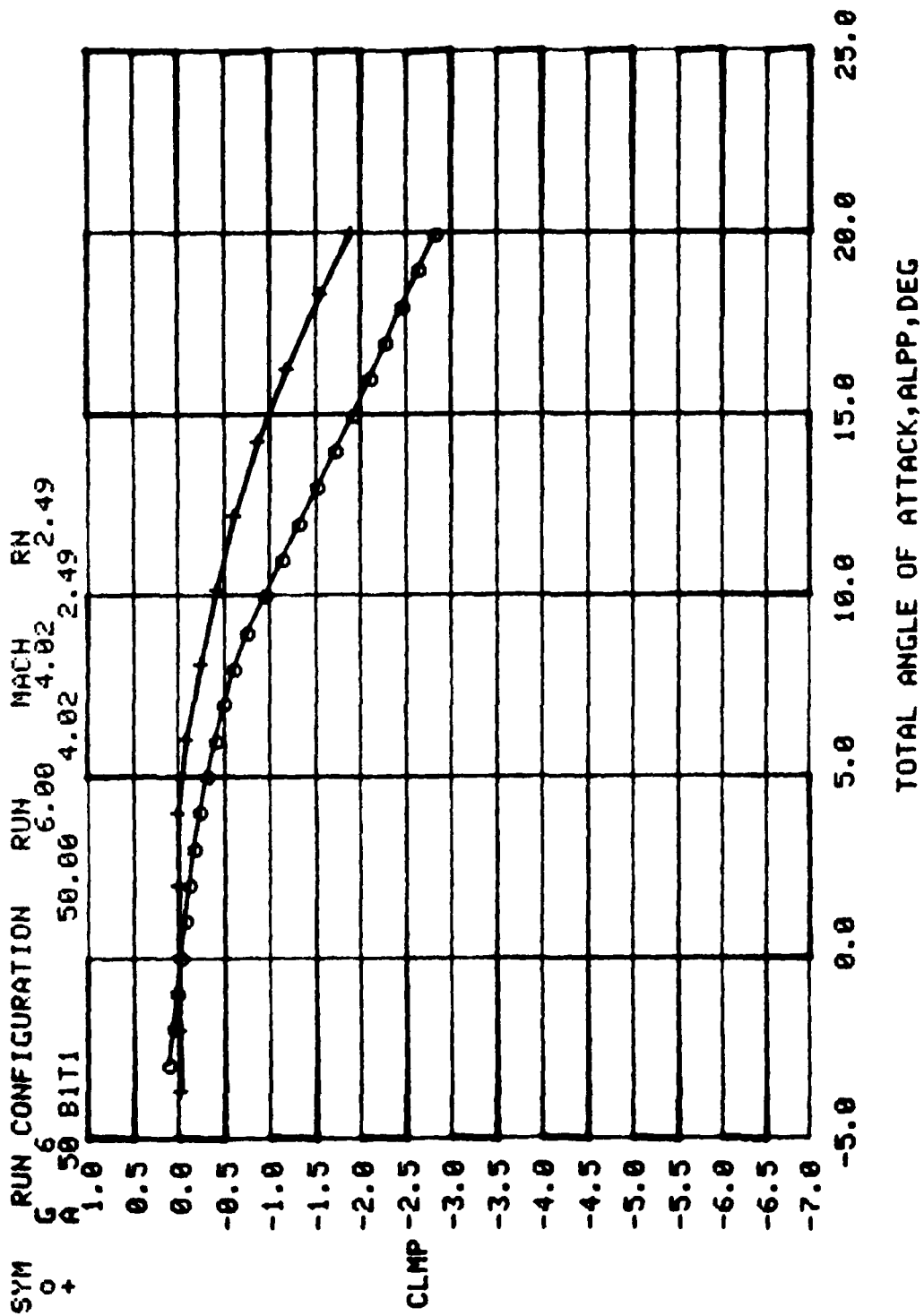
Figure 14. Body tail normal force vs angle of attack at M = 4.02.

SYM   RUN CONFIGURATION   RUN   MACH   RH
○   7   7.00 1.95   2.51
+   8 B1W1   8.00 1.95   2.50

CNP

10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0

-5.0   0.0   5.0   10.0   15.0   20.0   25.0

TOTAL ANGLE OF ATTACK,ALPP,DEG
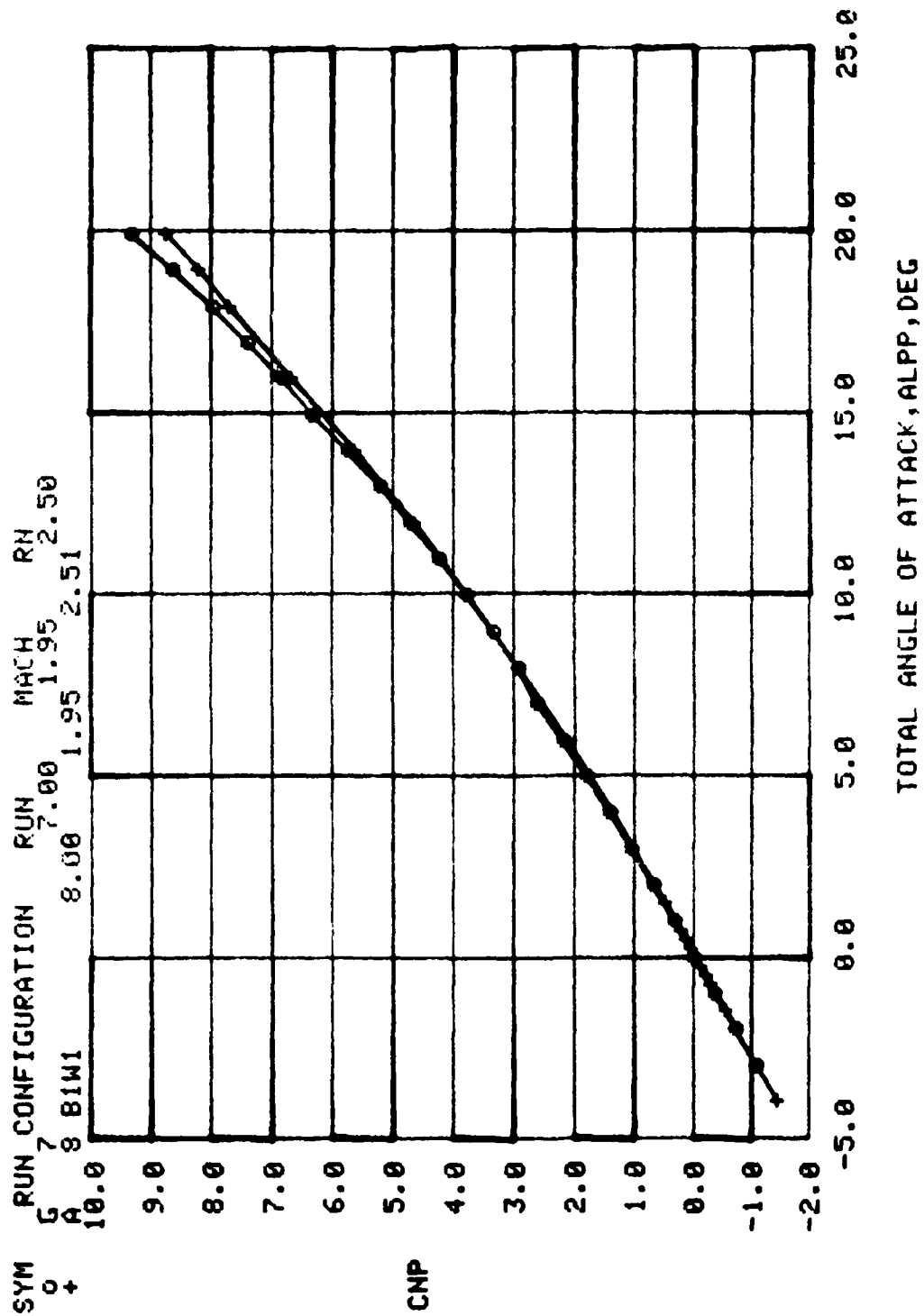
Figure 15. Body wing normal force vs angle of attack at M = 1.95.

30
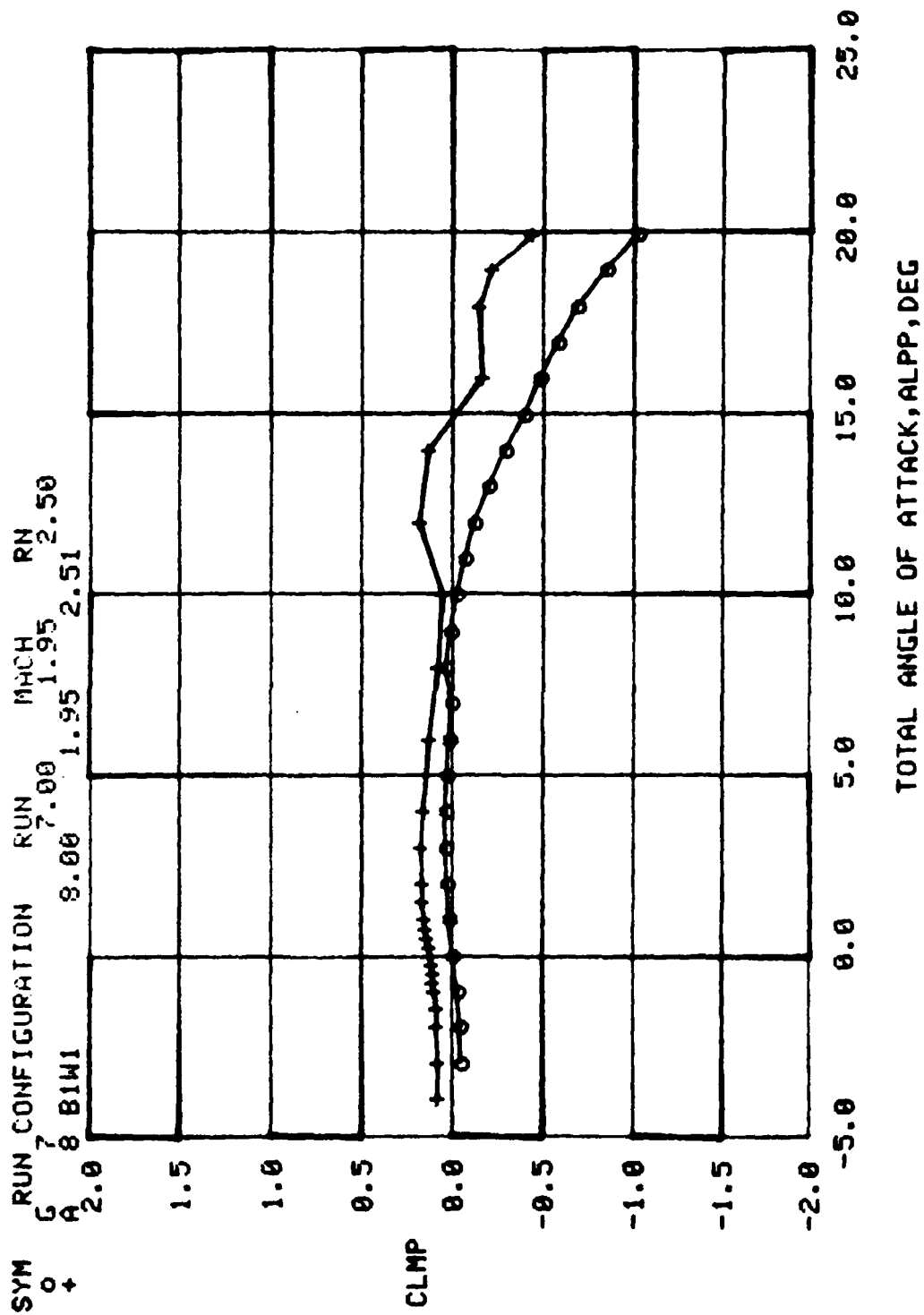
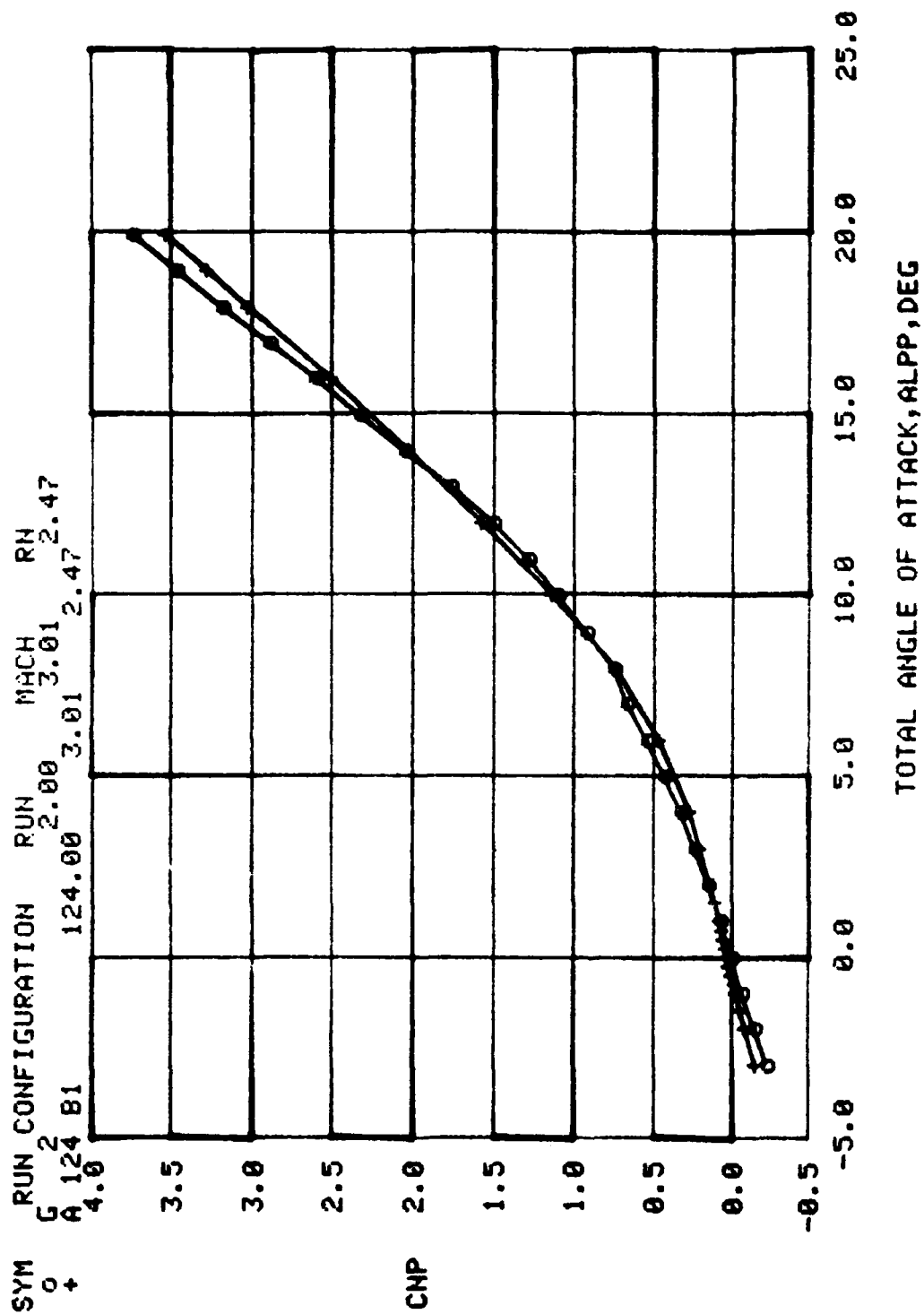Figure 16. Body wing pitching moment vs angle of attack at M = 1.95.

31
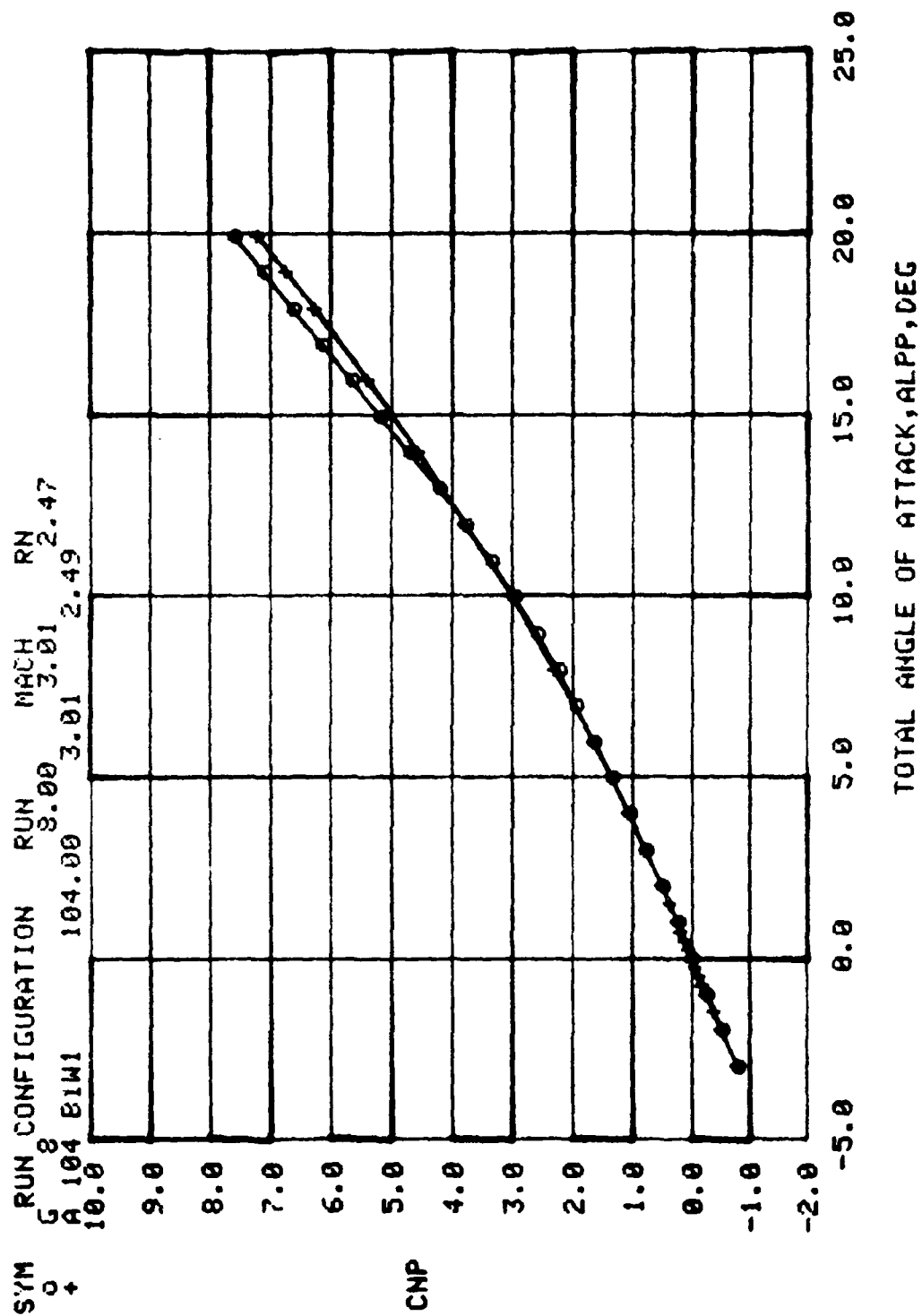
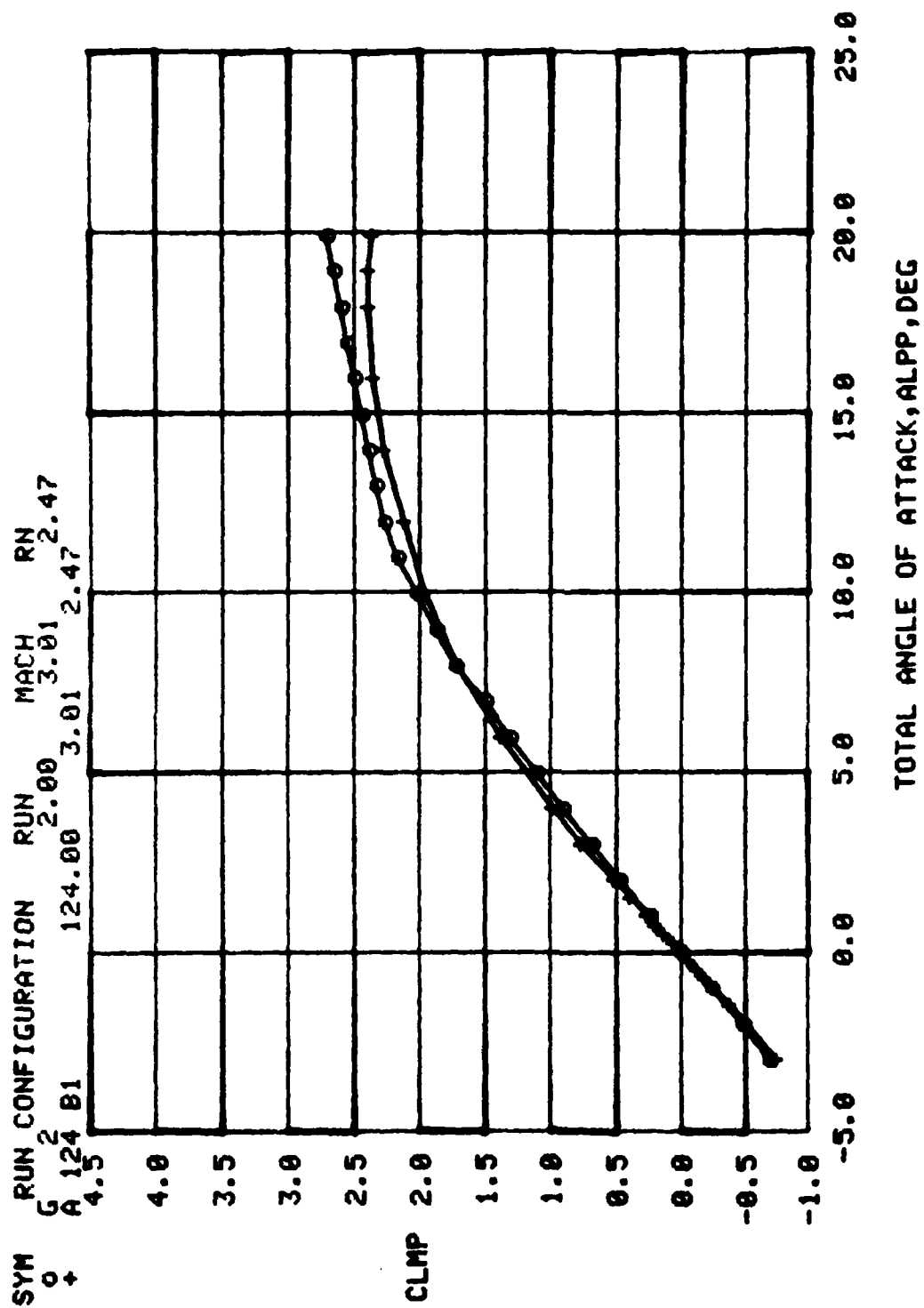Figure 17. Body wing normal force vs angle of attack at M = 3.01.

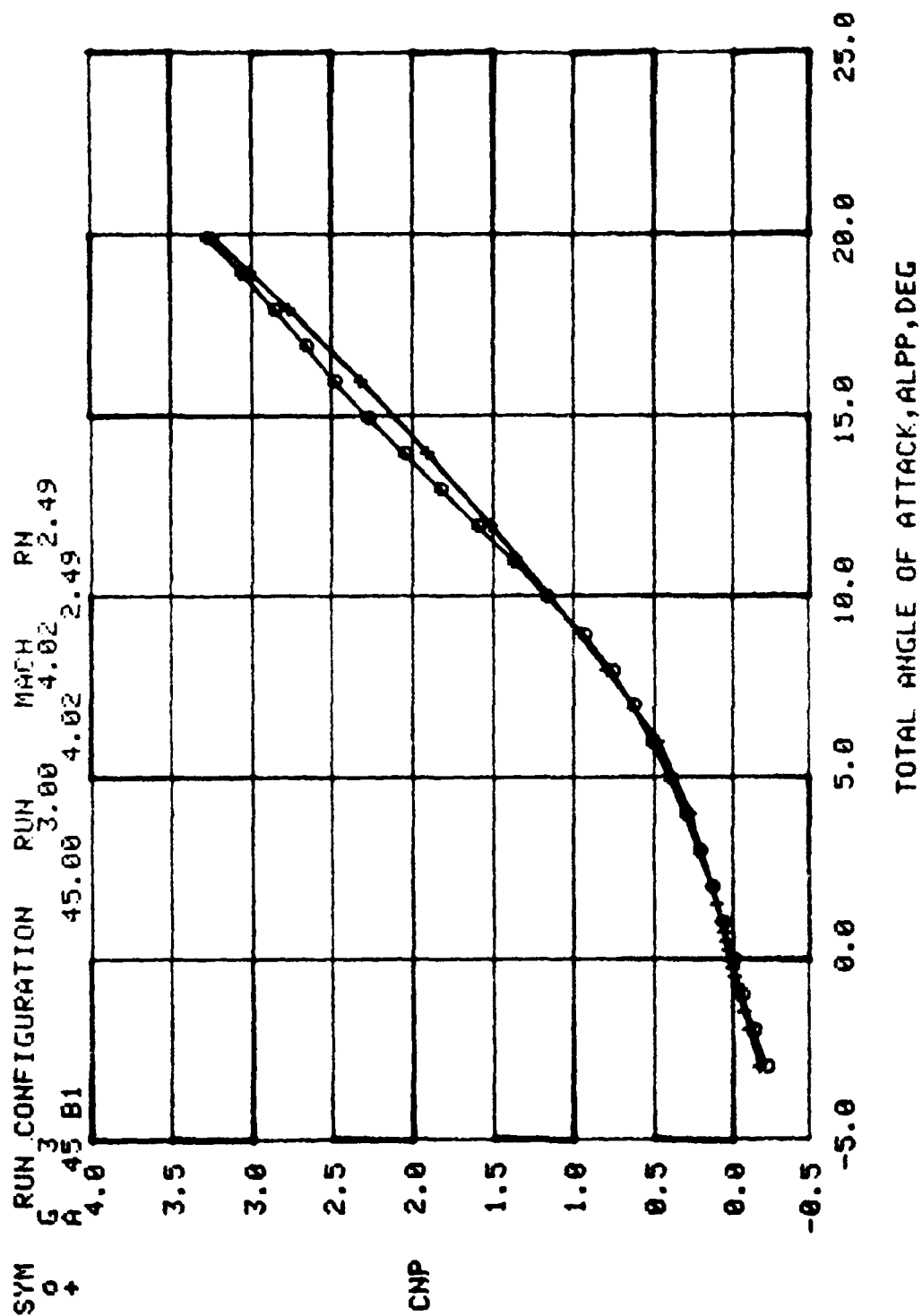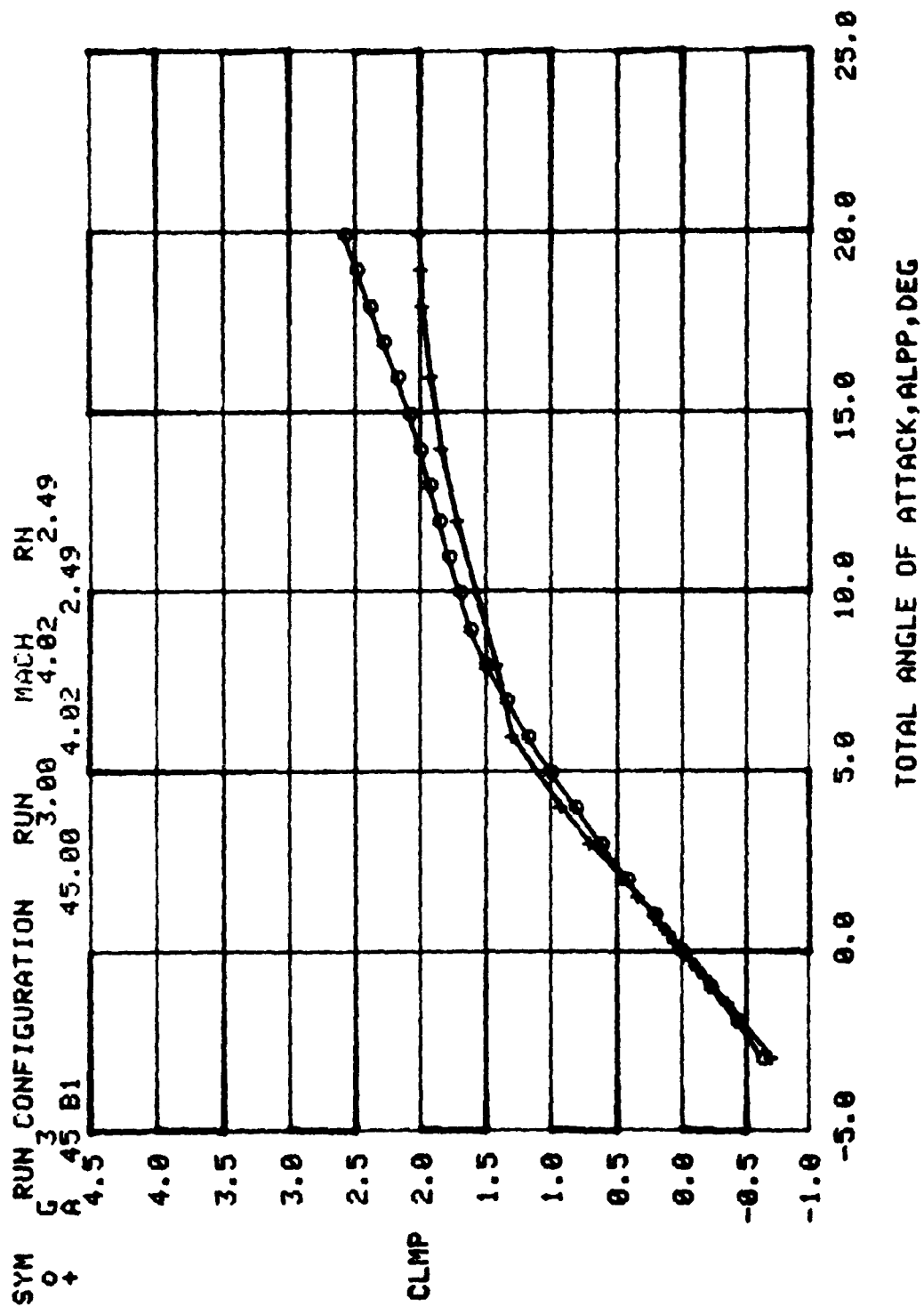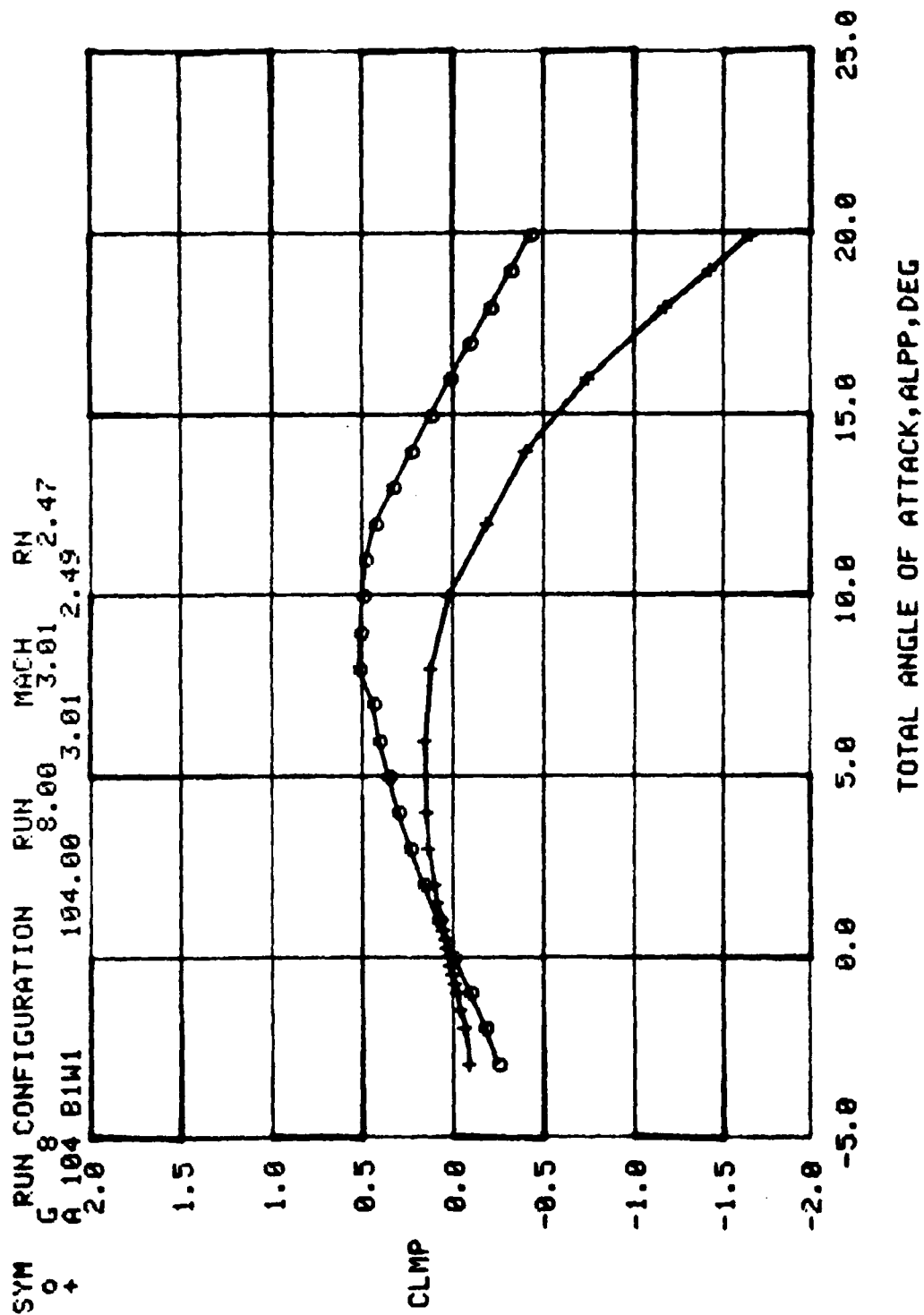Figure 18. Body wing pitching moment vs angle of attack at M = 3.01.

Figure 19. Body wing normal force coefficient vs angle of attack at M = 4.02.

Figure 20. Body wing pitching moment coefficient vs angle of attack at M = 4.02.

35

Figure 21. Body wing-tail normal force coefficient vs angle of attack at M = 1.95.

Figure 22. Body-wing-tail pitching moment coefficient vs angle of attack at $M = 1.95$.

37

Figure 23. Body-wing-tail normal force coefficient vs angle of attack at M = 3.01.

Figure 24. Body-wing-tail pitching moment coefficient vs angle of attack at M = 3.01.

39

Figure 25. Body-wing-tail normal force coefficient vs angle of attack at M = 4.02.

SYM RUN CONFIGURATION RUN MACH RN

O 12 64 B1W1T1 12.00 4.02 2.48

+ 64 64.00 4.02 2.49

CLMP

TOTAL ANGLE OF ATTACK,ALPP,DEG

Figure 26. Body-wing-tail pitching moment coefficient vs angle of attack at M = 4.02.

MOMENT REFERENCE CENTER STATION 31.35

Figure 27. Full-scale Copperhead model configuration.

SOURCE: Ref. 1

42
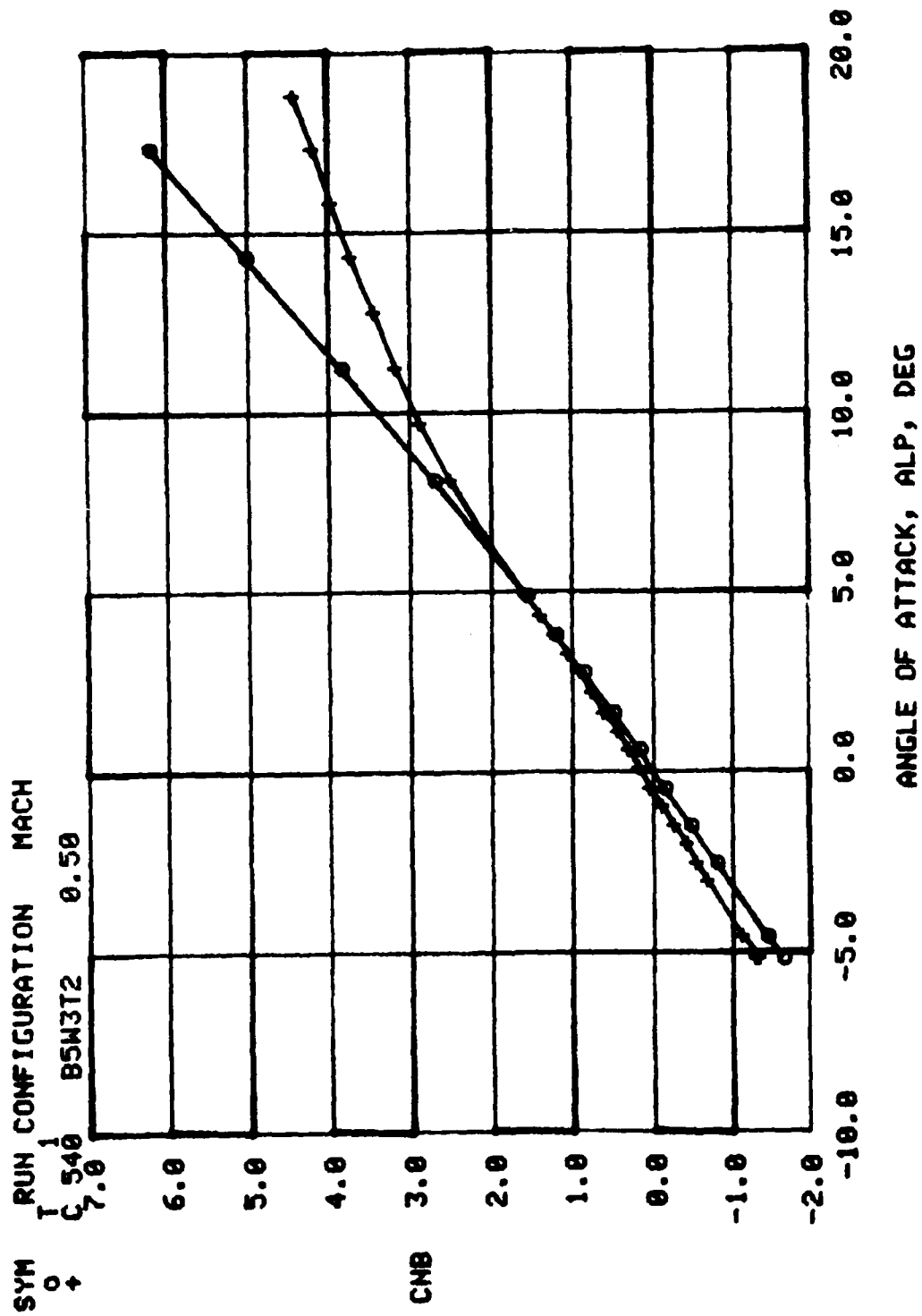
Figure 28. Normal force coefficient vs angle of attack at $M\infty = 0.5$.

Figure 29. Pitching moment coefficient vs angle of attack at M∞ = 0.5.

44

Figure 30. Normal force coefficient vs angle of attack at $M_\infty = 0.8$.

45

SYM RUN CONFIGURATION MACH

○ 546 B5W3T2 0.80

+

ANGLE OF ATTACK, ALP, DEG

CMB

2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0

-10.0 -5.0 0.0 5.0 10.0 15.0 20.0

Figure 31. Pitching moment coefficient vs angle of attack at M∞ = 0.8.

Figure 32. Normal force coefficient vs angle of attack at $M_\infty = 0.95$.

47

Figure 33. Pitching moment coefficient vs angle of attack at $M_\infty = 0.95$.

48
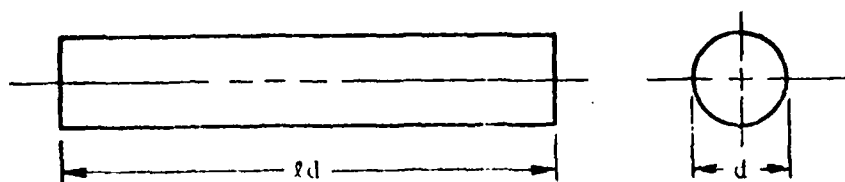
AFTERBODY CONFIGURATION	d (in.)	ℓ
A1	3.75	7.00
A2	3.75	7.50
A3	3.75	8.25
A4	3.75	9.50
A5	3.75	11.50
A6	4.00	7.00
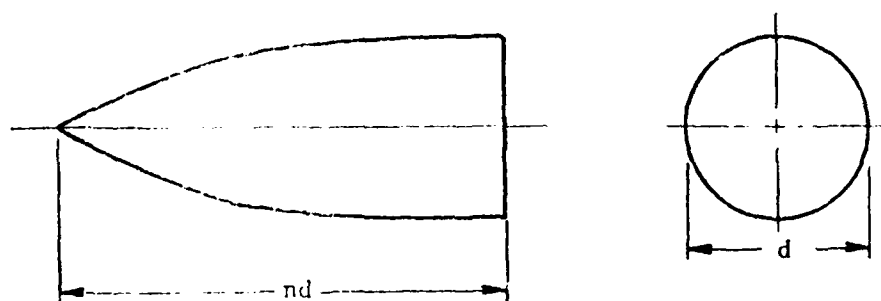
NOSE CONFIGURATION	GEOMETRY	d (in.)	n
N1	TANGENT OGIVE	3.75	3.0
N2	TANGENT OGIVE	3.75	2.5
N3	CONE	3.75	3.0
N4	SECANT OGIVE	4.00	2.0

NOTE: ALL MOMENTS REFERENCED TO NOSE (STA. 0.0)

Figure 34. Nose-afterbody nomenclature.

49

4°

3.480

6.960

W1

0.232

4°

2.812

5.625

W2

0.187

4°

1.875

3.750

W3

0.125
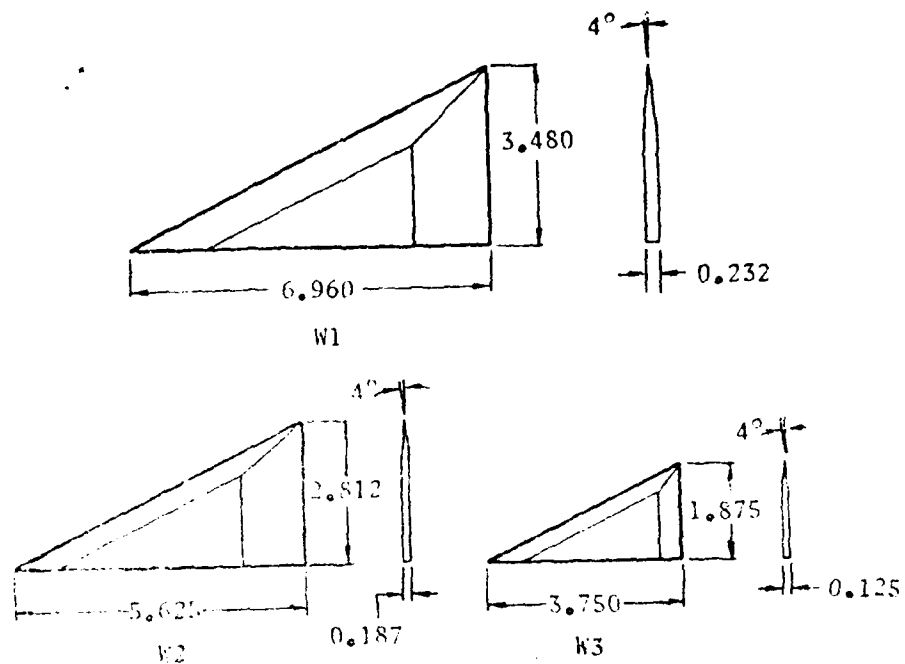
DIMENSIONS IN INCHES

Figure 35. Wing configurations (Tests "F" and "I").
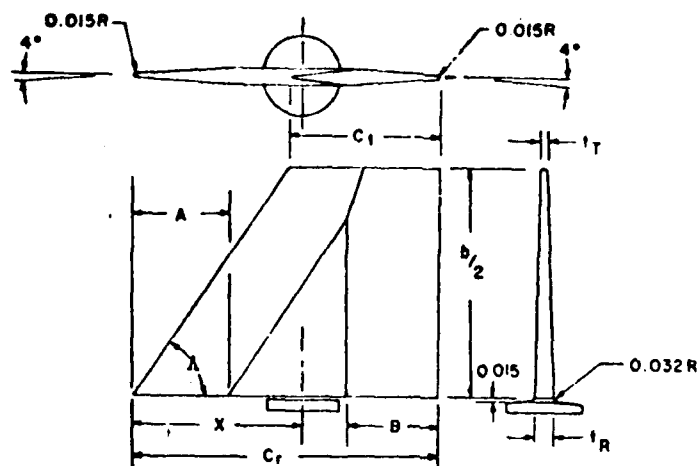
Tail Fin Config.	S_f, in.^{2}	AR	b/2, in.	λ		A, in.	C_t, in.	B, in.	C_r, in.	X/C_r	t_r, in.	t_t
11	7.028	1.0	1.875	1.0	90°	0.800	3.749	0.800	3.749	0.45	0.140	0.140
12	7.942	2.0	2.821	0	26°34'	1.172	0	1.140	5.625	0.62	0.187	0.187
13	7.916	2.0	2.821	0.5	56°19'	1.158	1.873	1.140	3.749	0.55	0.187	0.187
14	7.038	1.0	1.875	0	14°3'	1.195	0	1.140	7.499	0.62	0.187	0.187
15	7.024	1.0	1.875	0.5	36°51'	1.165	2.497	1.140	4.996	0.55	0.187	0.187
16	7.916	2.0	2.821	1.0	90°	0.800	2.813	0.800	2.813	0.45	0.140	0.140
21	3.513	2.0	1.875	1.0	90°	0.696	1.874	0.696	1.874	0.45	0.125	0.125
22	3.509	2.0	1.875	0	26°34'	0.728	0	0.694	3.749	0.62	0.125	0.125
23	3.605	2.0	1.875	0.5	55°38'	0.717	1.282	0.694	2.565	0.55	0.125	0.125
31	14.030	0.5	1.875	0.5	20°36'	1.624	4.990	1.587	9.980	0.55	0.250	0.125
32	14.036	0.5	1.875	1.0	90°	1.587	7.499	1.587	7.499	0.45	0.250	0.250
33	19.235	2.0	4.385	1.0	90°	1.587	4.395	1.587	4.395	0.45	0.250	0.250
34	18.373	2.0	4.385	0.5	57°35'	1.606	2.792	1.587	5.585	0.55	0.250	0.125
35	19.212	2.0	4.385	0	26°37'	1.619	0	1.587	8.771	0.55	0.250	0.250
36	14.056	0.5	1.875	0	7°8'	1.682	0	1.587	14.998	0.55	0.250	0.250

SOURCE: Ref. 4

Figure 36. Details of straight fin configurations.
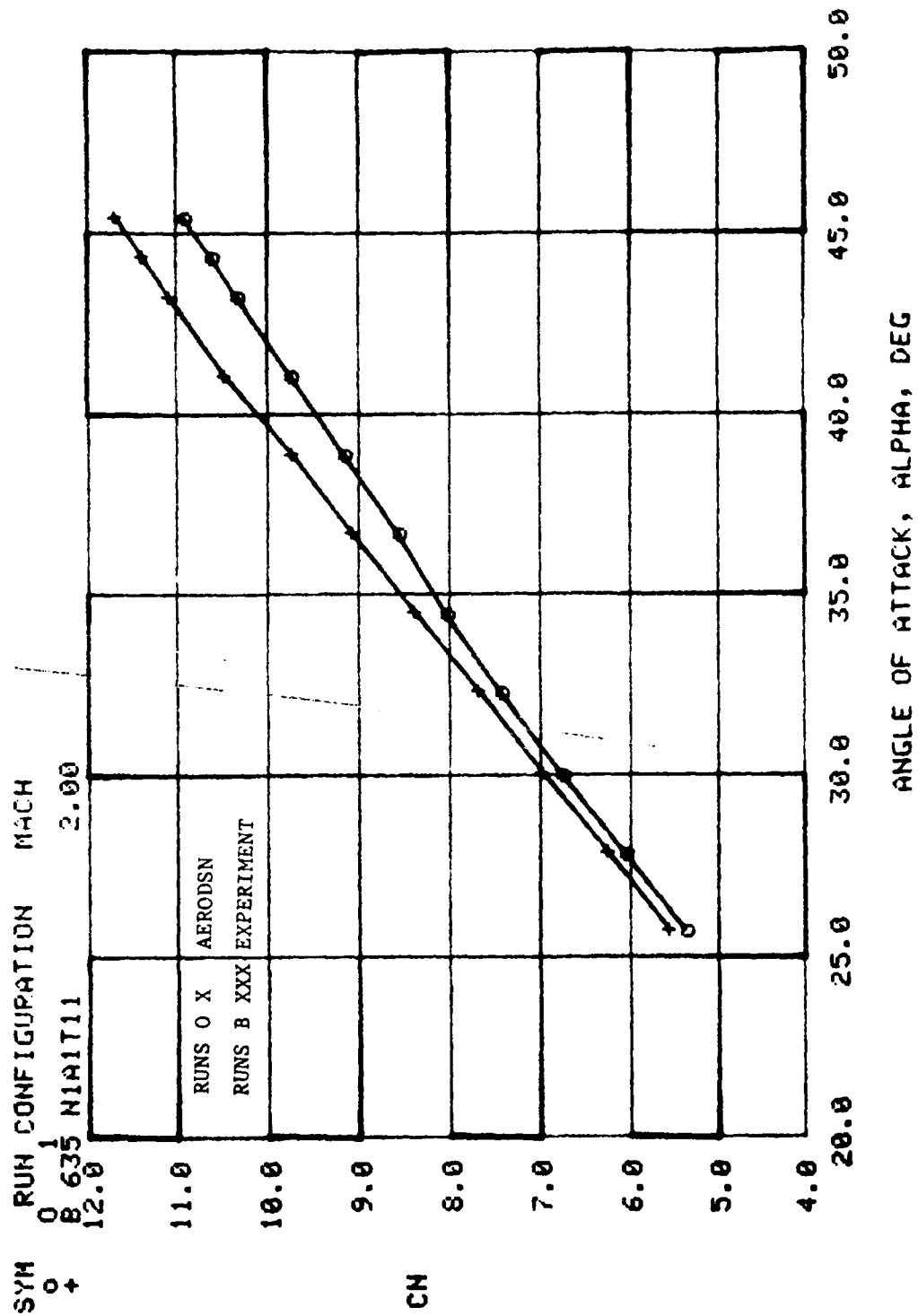
Figure 37. Normal force coefficient vs angle of attack at $M_\infty = 2.0$.

52
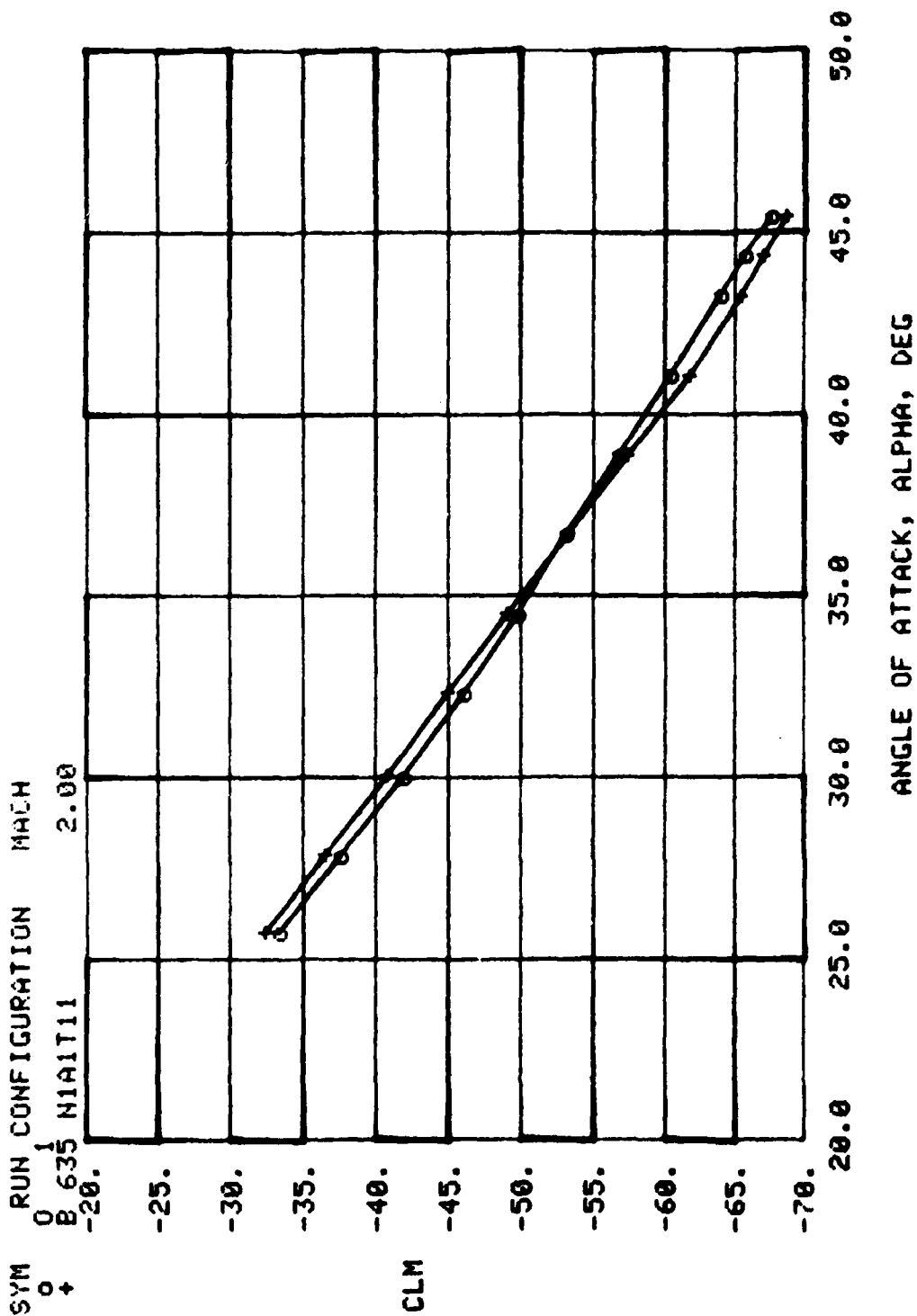
Figure 38. Pitching moment coefficient vs angle of attack at $M\infty = 2.0$.
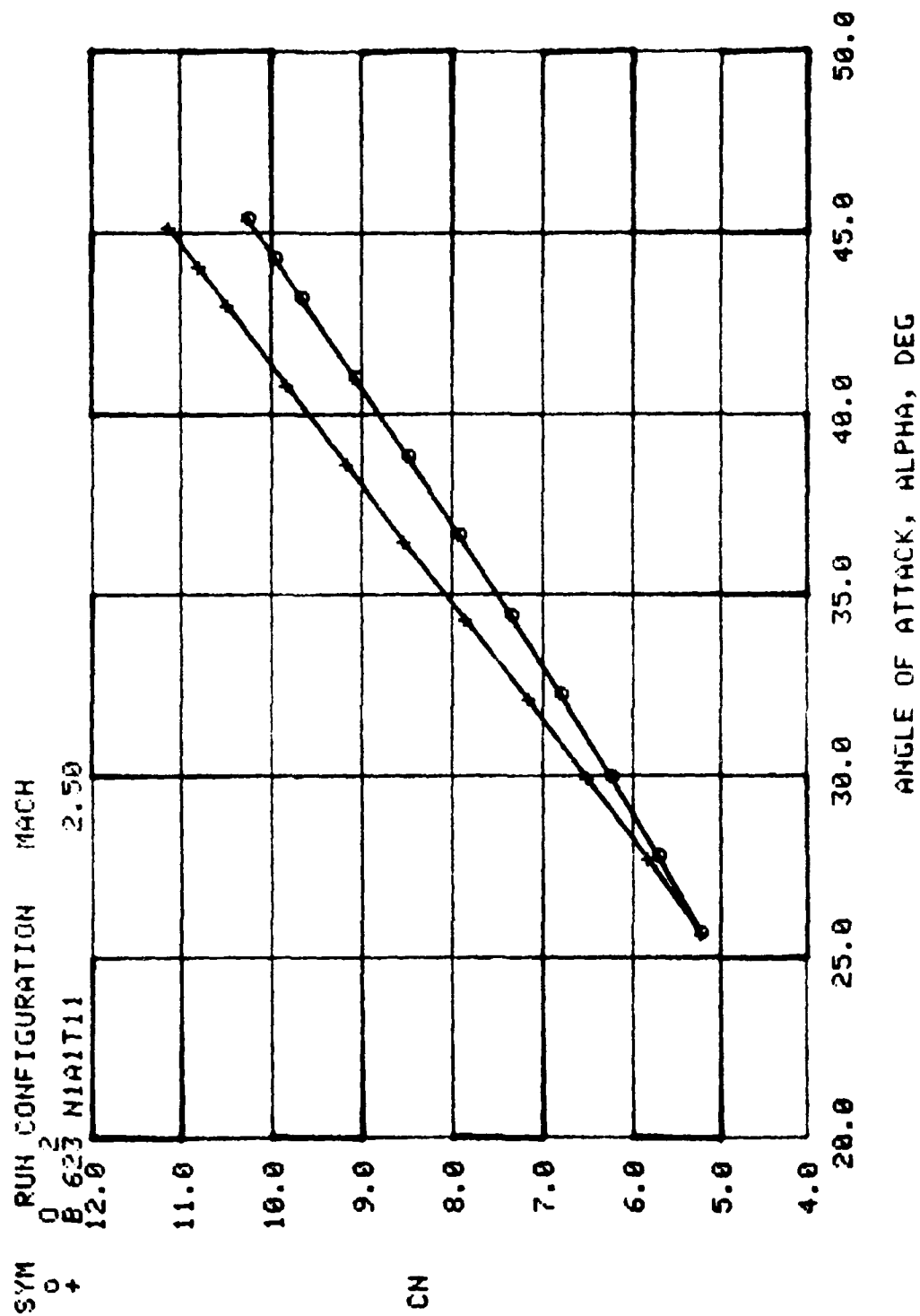
Figure 39. Normal force coefficient vs angle of attack at Mr = 2.5.

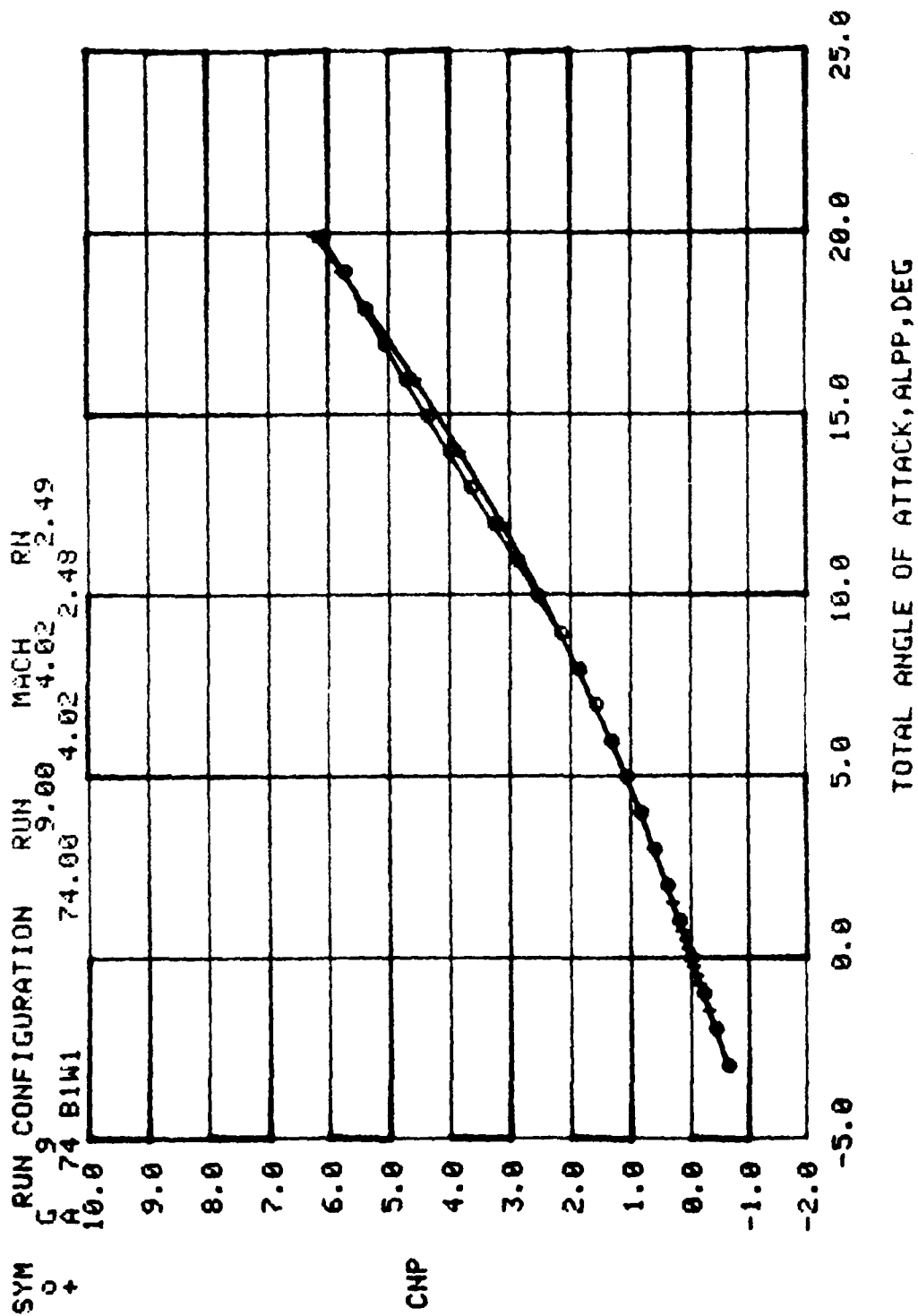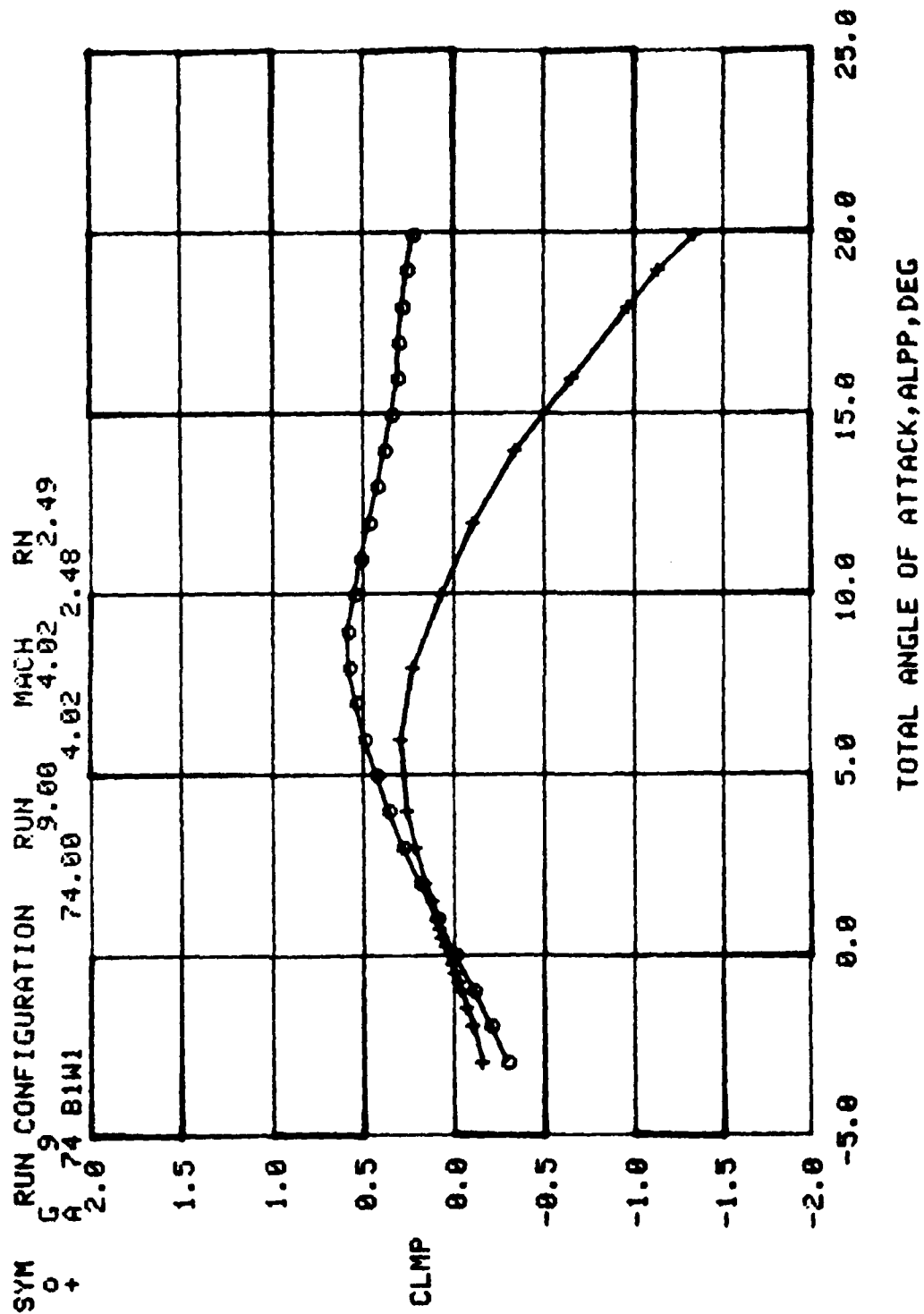Figure 40. Pitching moment coefficient vs angle of attack at $M\infty$ = 2.5.

55
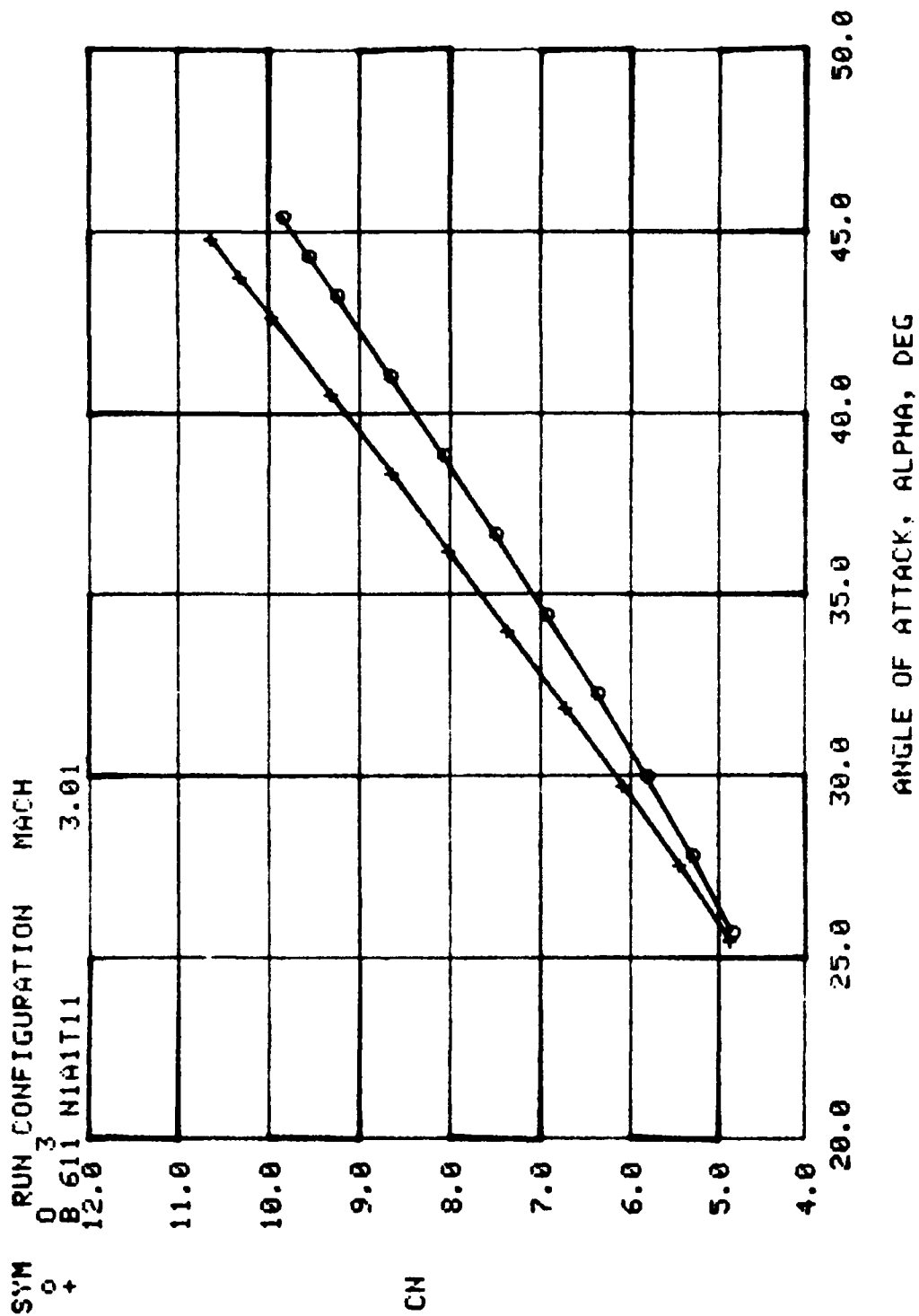
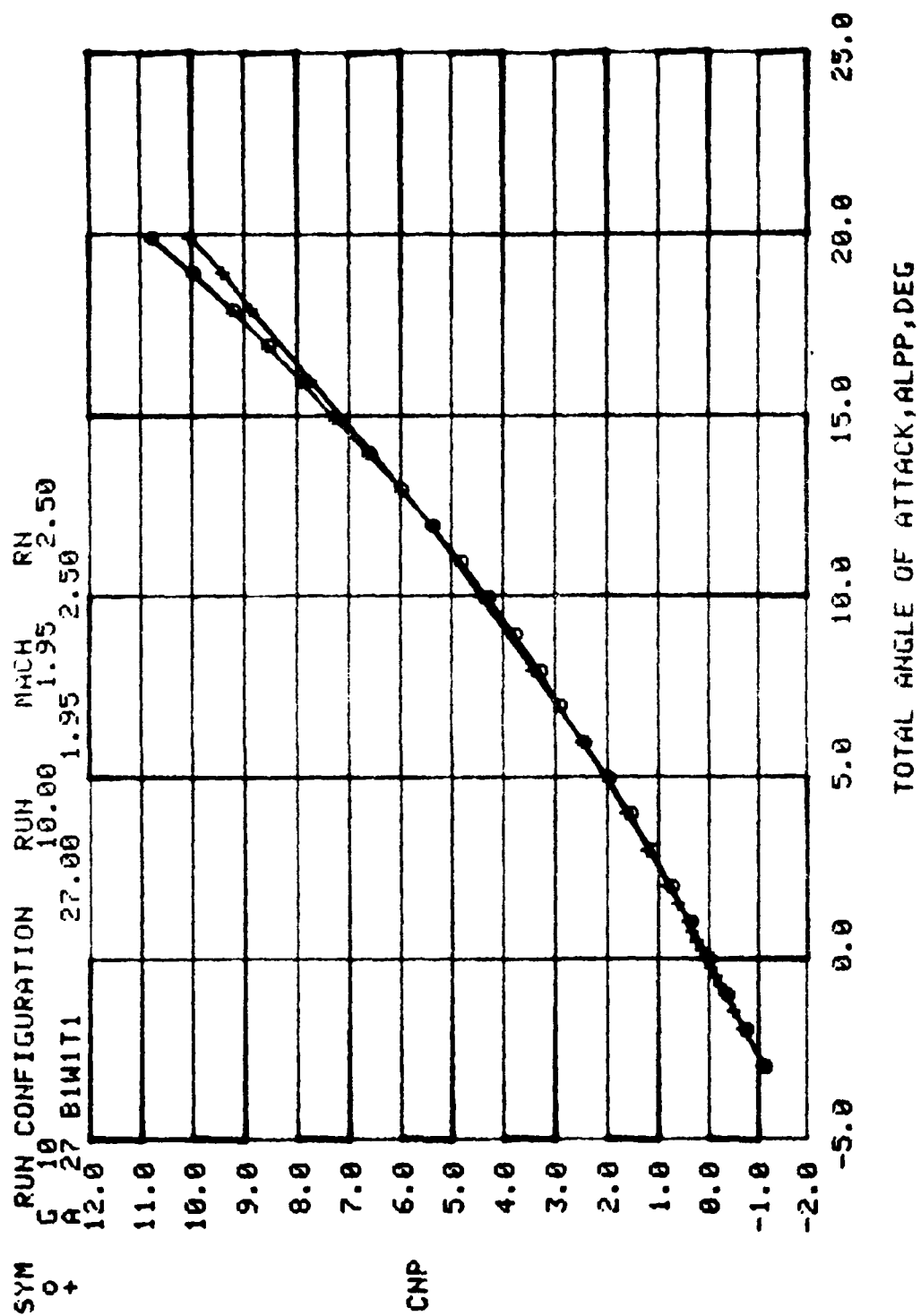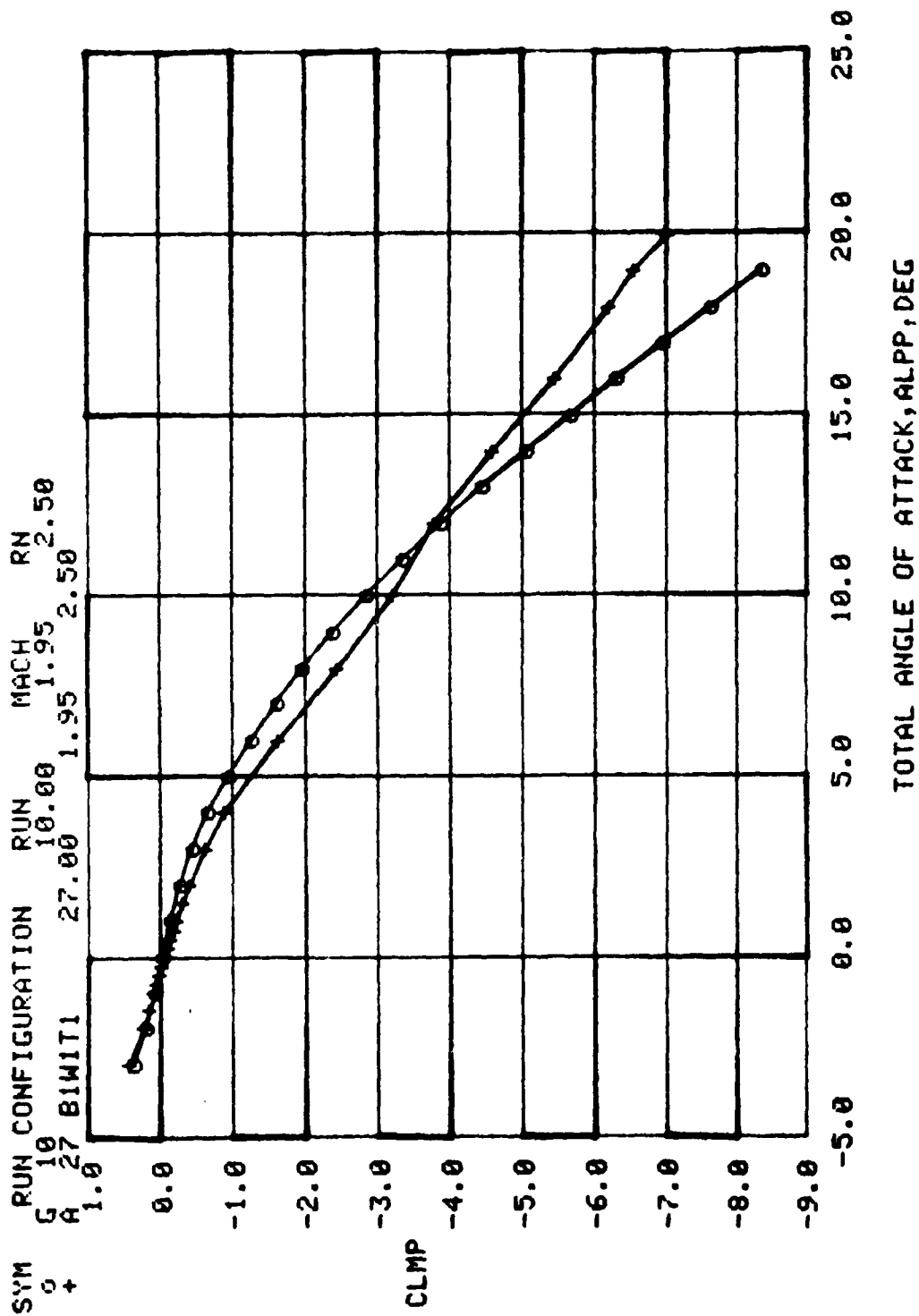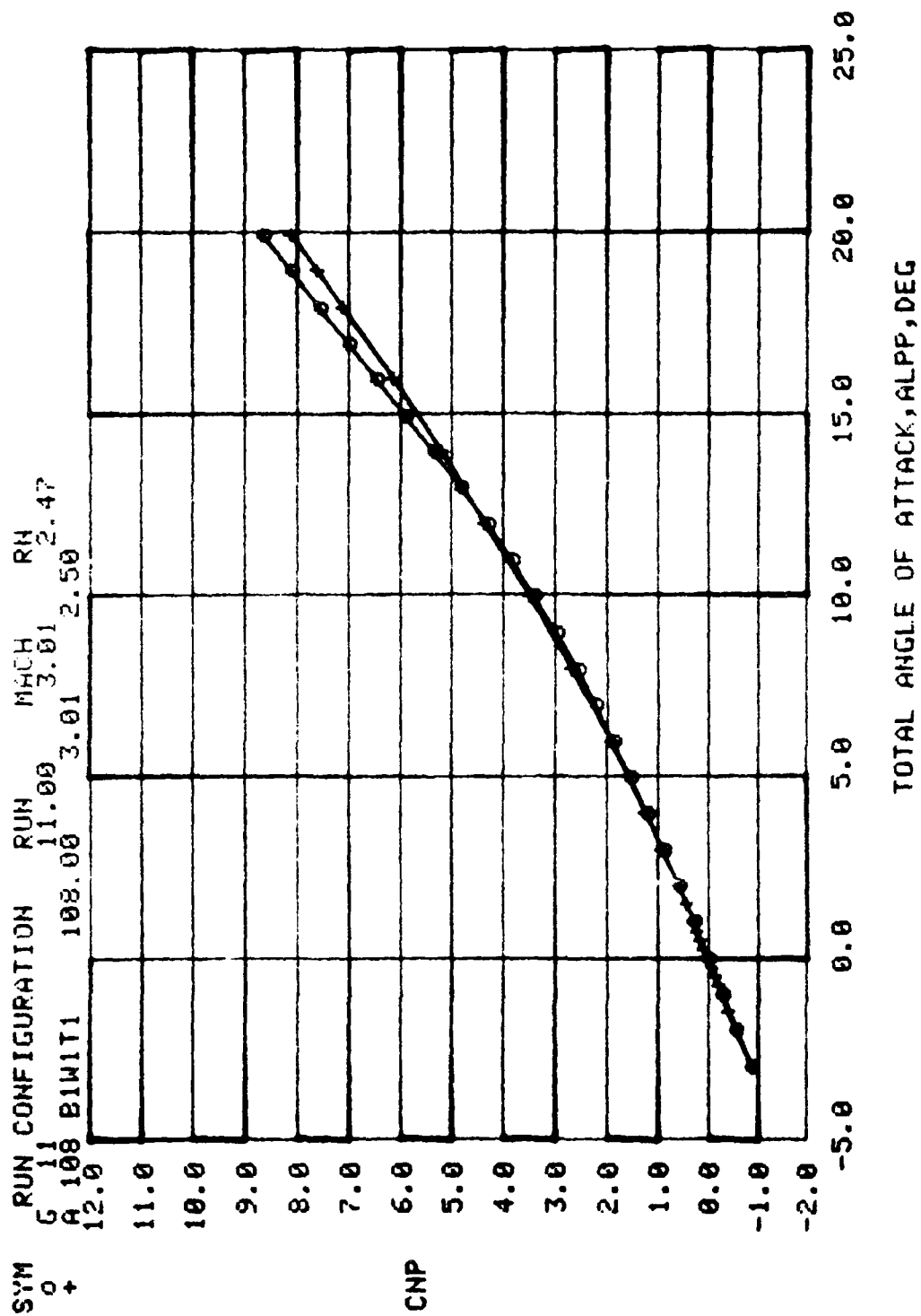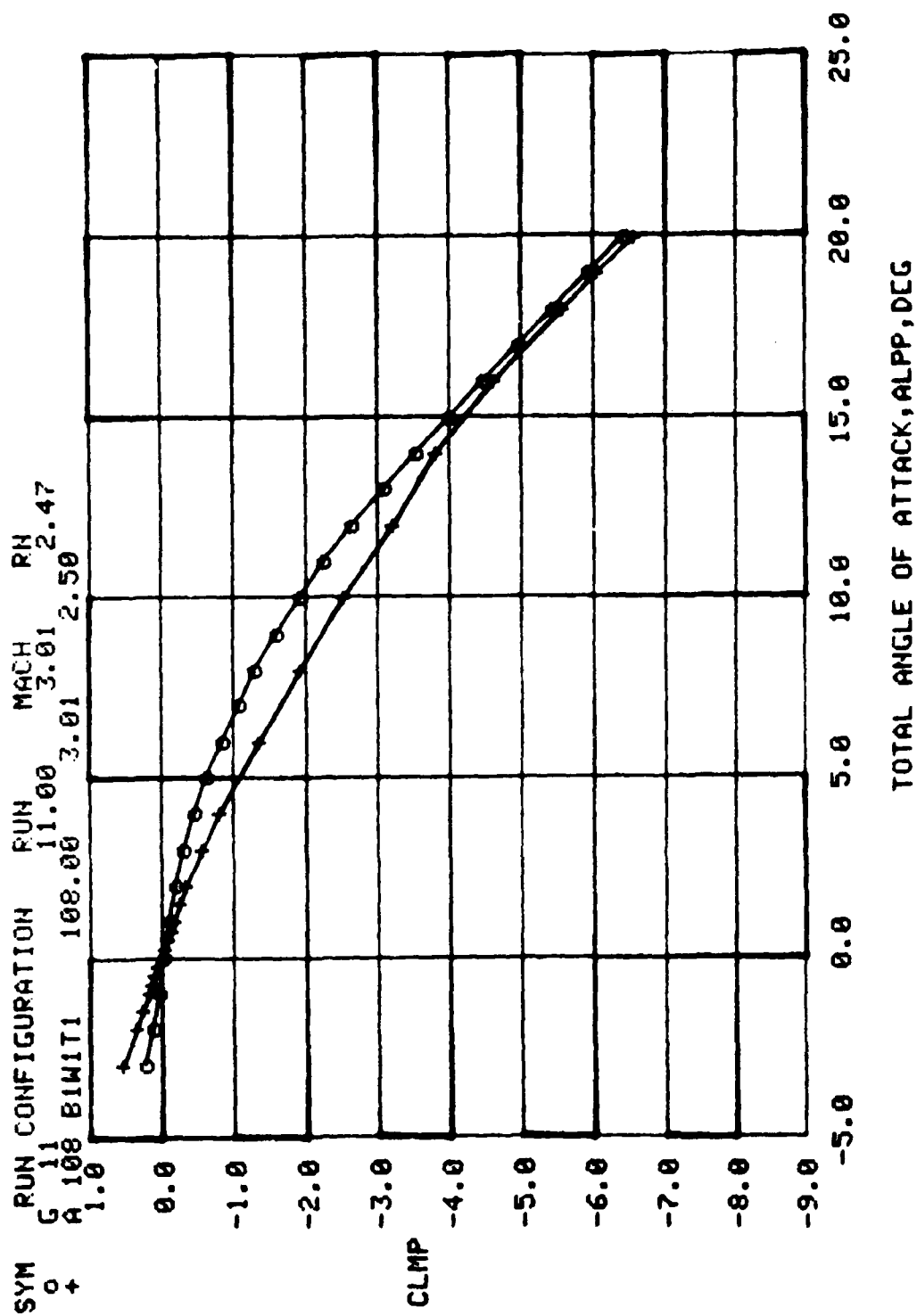Figure 41. Normal force coefficient vs angle of attack at $M_\infty = 3.01$.

56
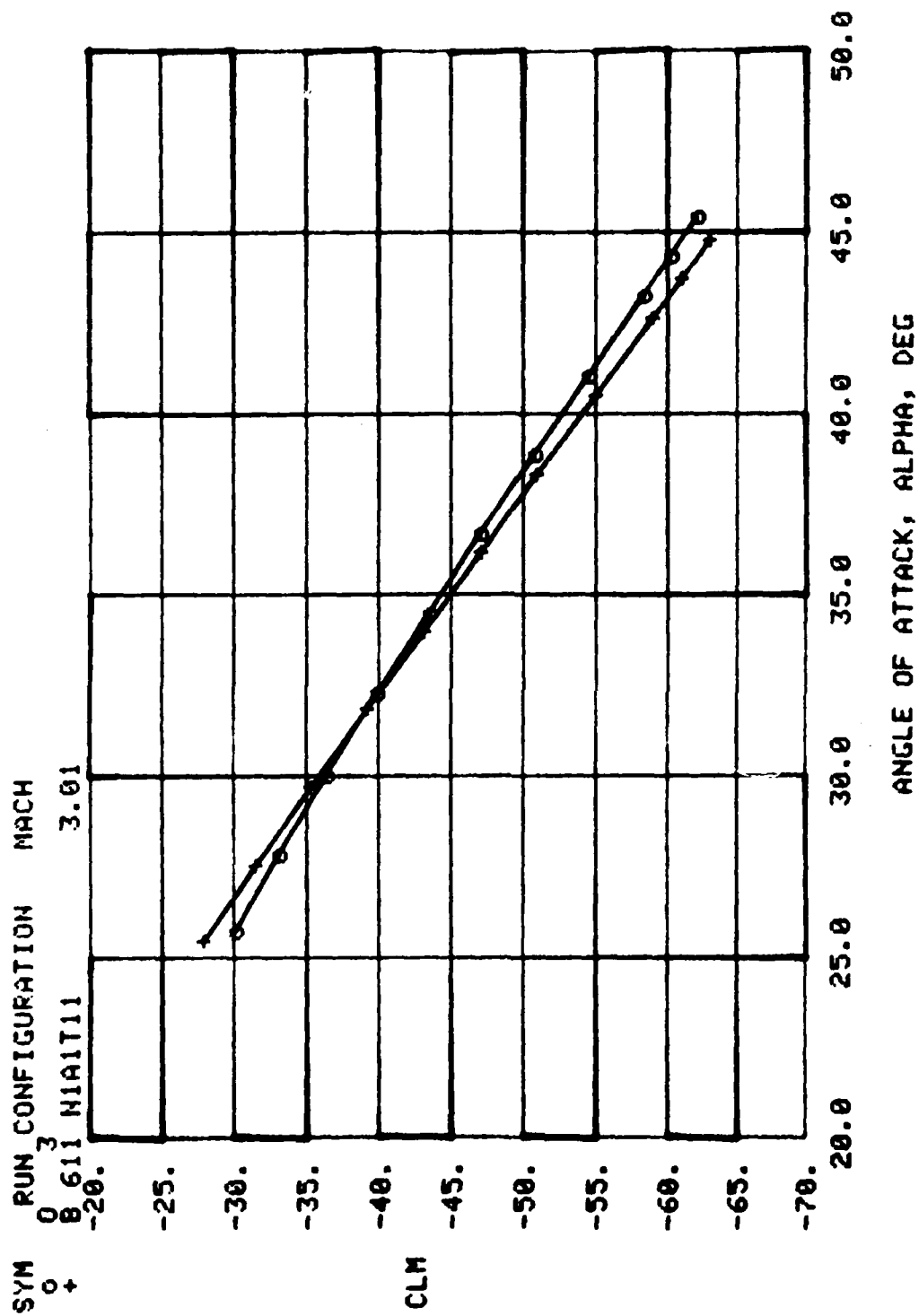
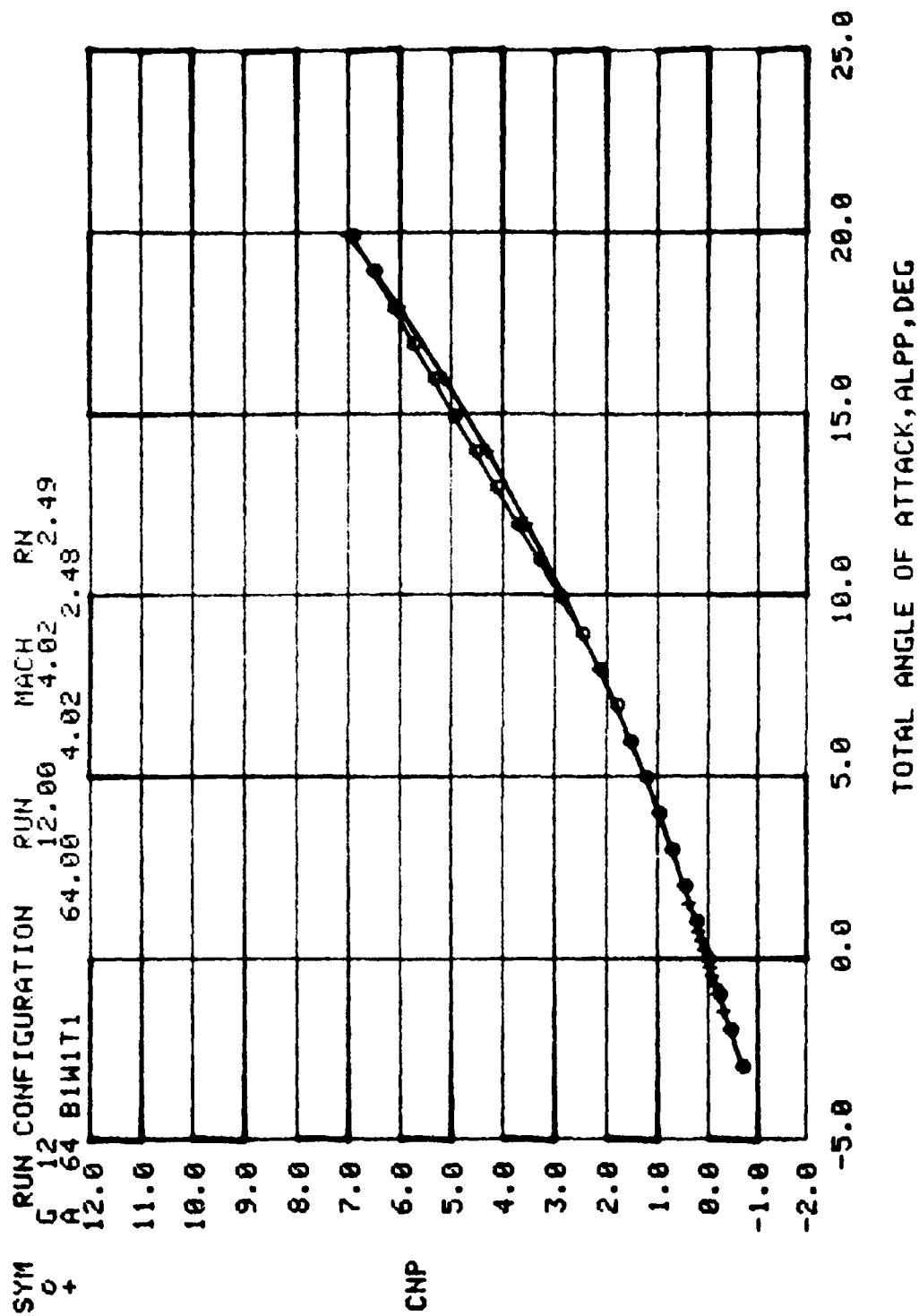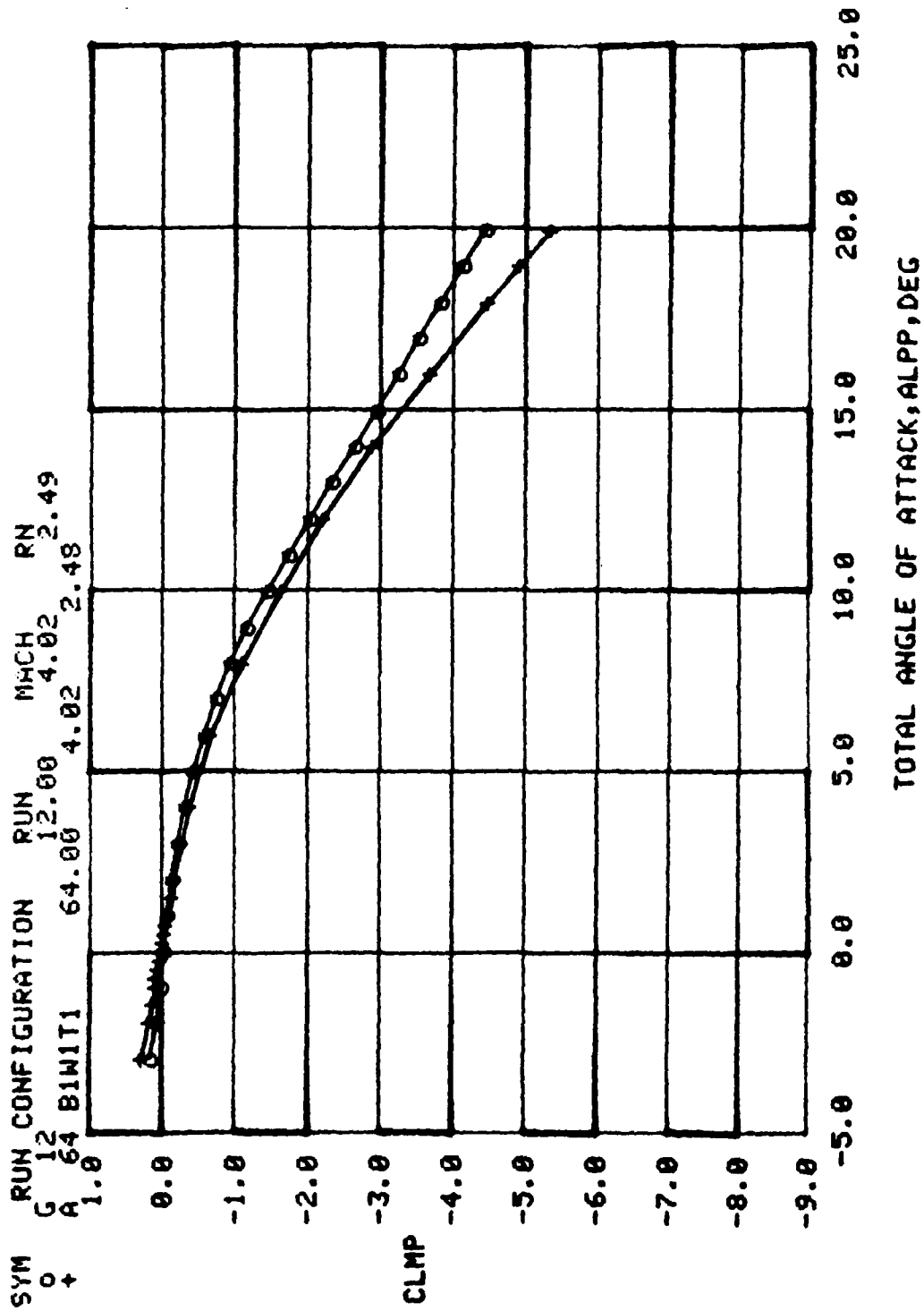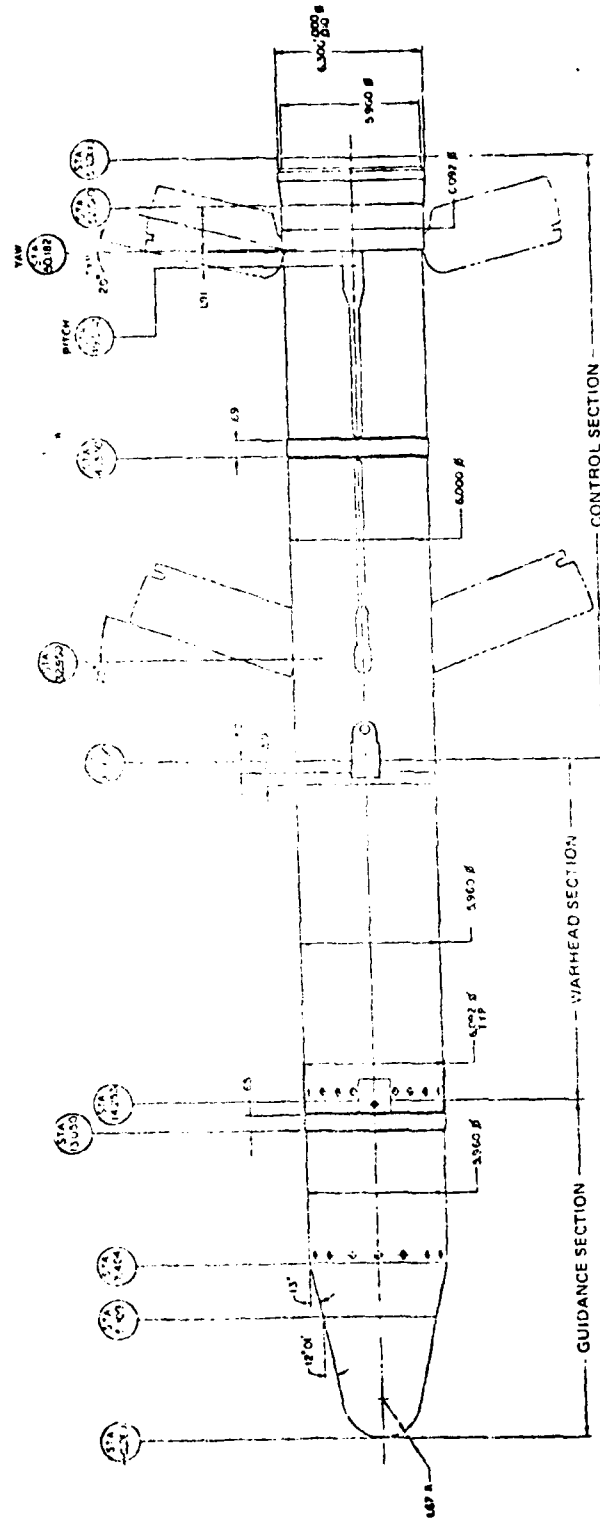Figure 42. Pitching moment coefficient vs angle of attack at $M\infty$ = 3.01.

Figure 43. Configuration B1 model geometry.

Orifice No.	Axial Location, x/ℓ
1	0.870
2	0.880
3	0.892
4	0.903
5	0.914
6	0.925
7	0.930
8	0.936
9	0.942
10	0.947
11	0.953
12	0.958
13	0.964
14	0.987
15	0.993
16	0.998
17	0.947
18	0.953
19	0.958
20	0.964
21	0.975
22	0.975

2.272 R
2.372 R
2.500 R
36 deg
1.409
0.249
1.908

FIN F2 PROJECTED ASPECT RATIO = 2.74

3.068
0.920
2.146
1.490
1.680
2.943

ALL DIMENSIONS IN INCHES

30 deg
0.050 R

SECTION A—A

0.920
3.992
2.770
3.120
2.943
3.068

FIN F1 PROJECTED ASPECT RATIO = 1.48
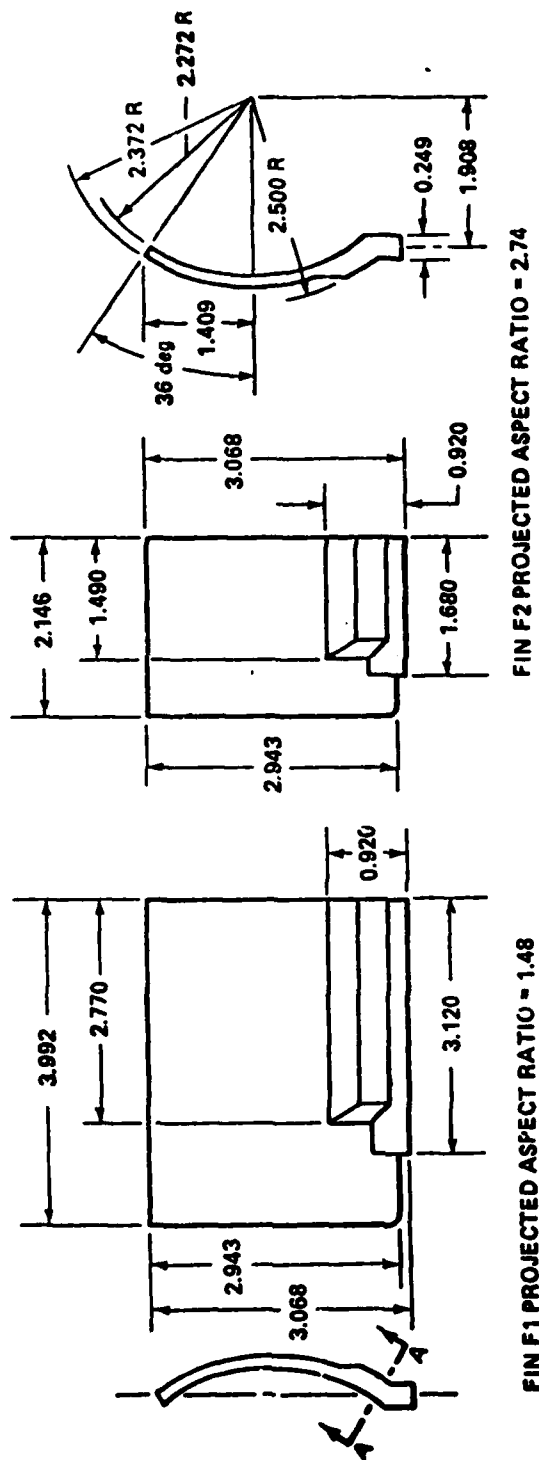
Figure 44. Fin details.

Figure 45. Normal force coefficient vs angle of attack at $M\infty = 0.2$.

60
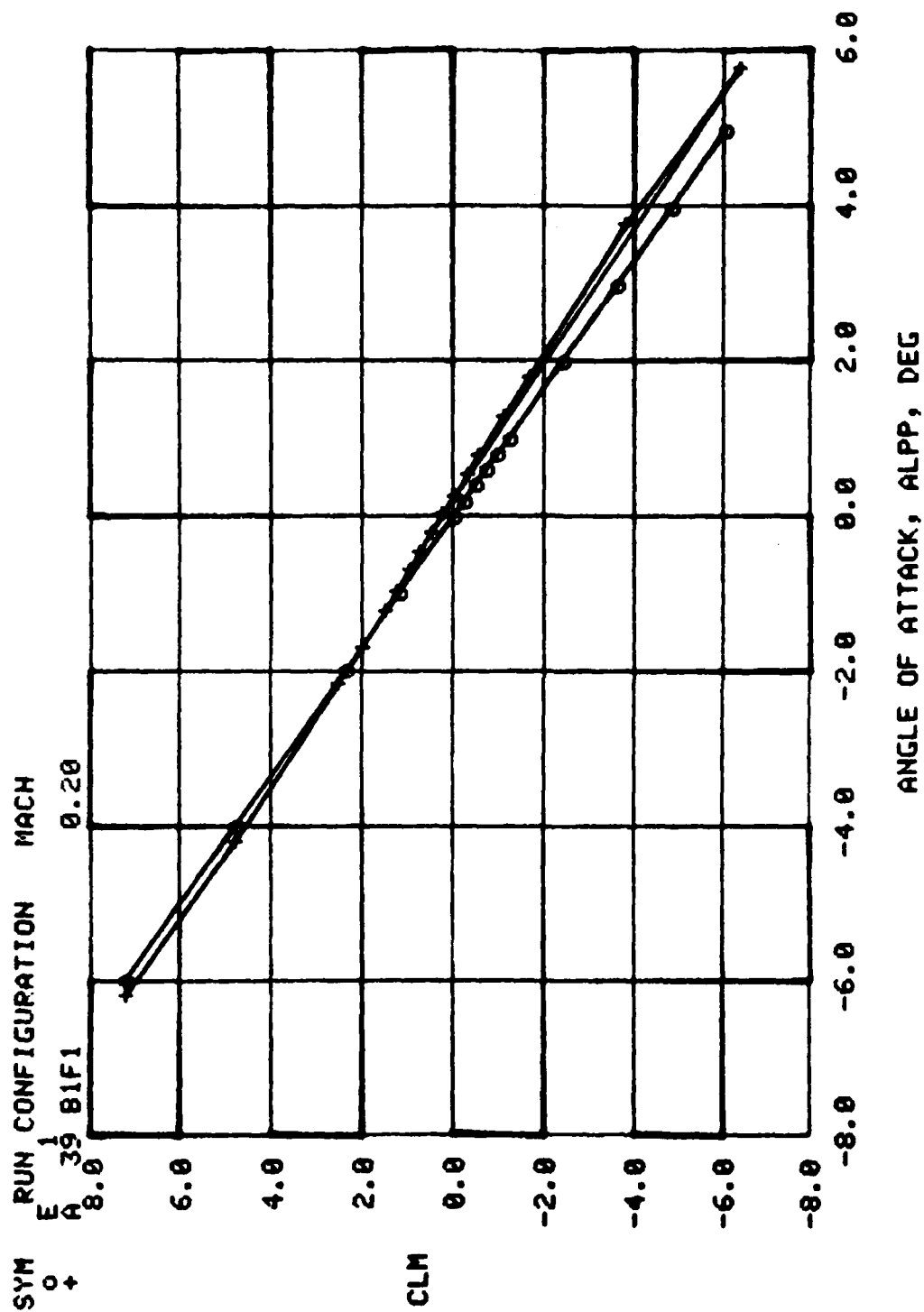
Figure 46. Pitching moment coefficient vs angle of attack at $M\infty = 0.2$.

SYM   RUN CONFIGURATION   MACH
o   E   0.40
+   A 44   B1F1

CN

1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0

-8.0   -6.0   -4.0   -2.0   0.0   2.0   4.0   6.0

ANGLE OF ATTACK, ALPP, DEG
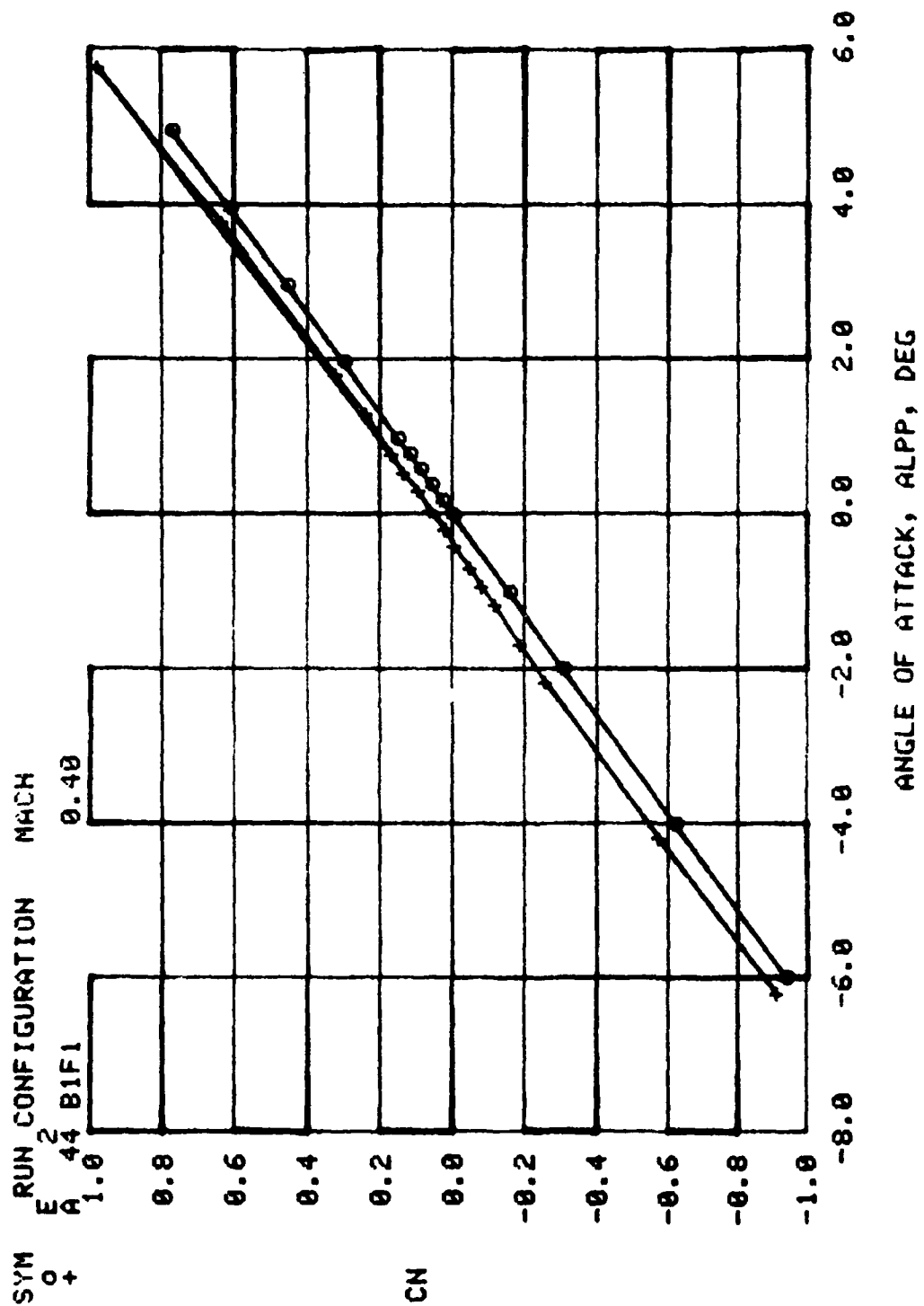
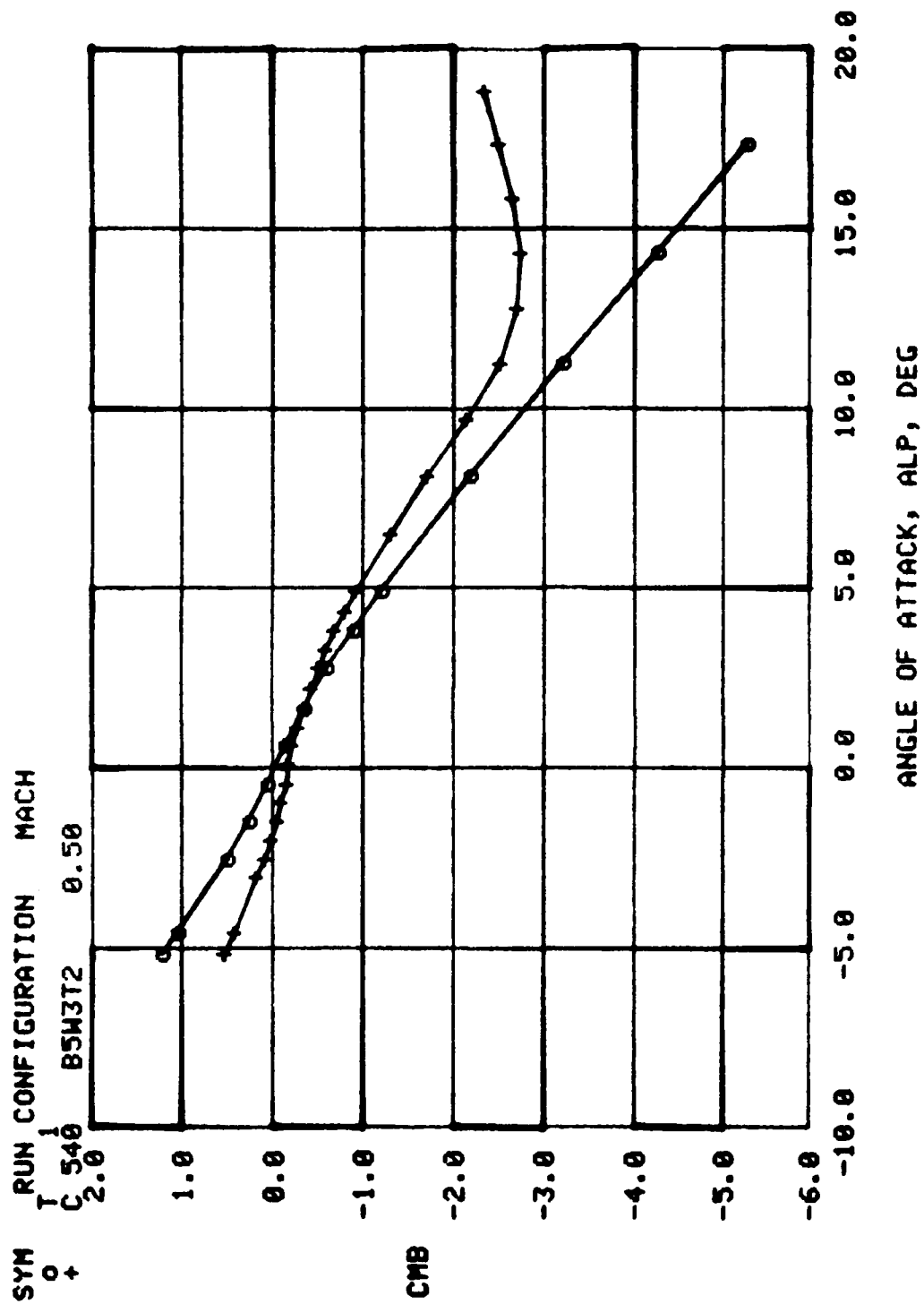Figure 47. Normal force coefficient vs angle of attack at M∞ = 0.4.
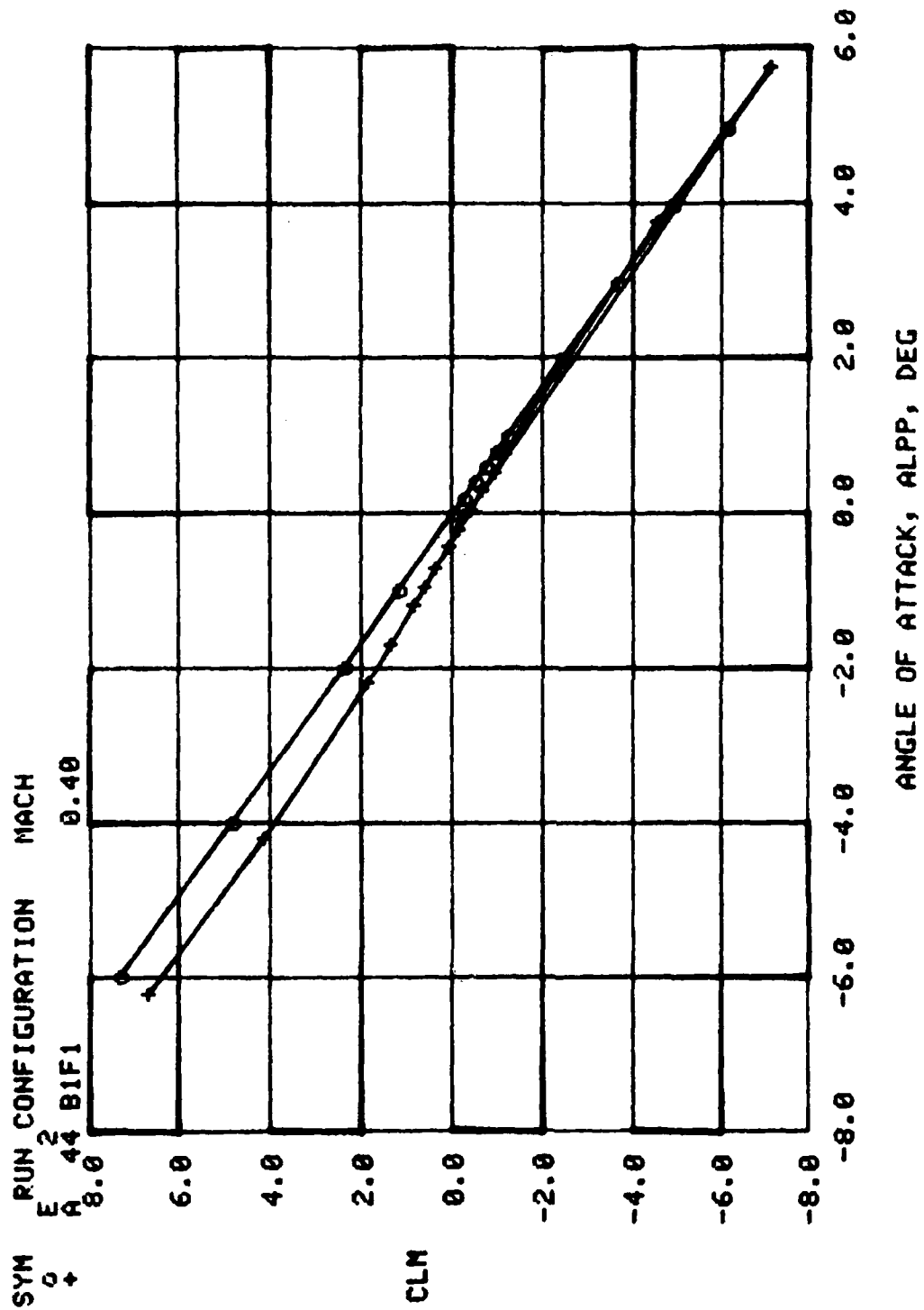
Figure 48. Pitching moment coefficient vs angle of attack at $M\infty = 0.4$.
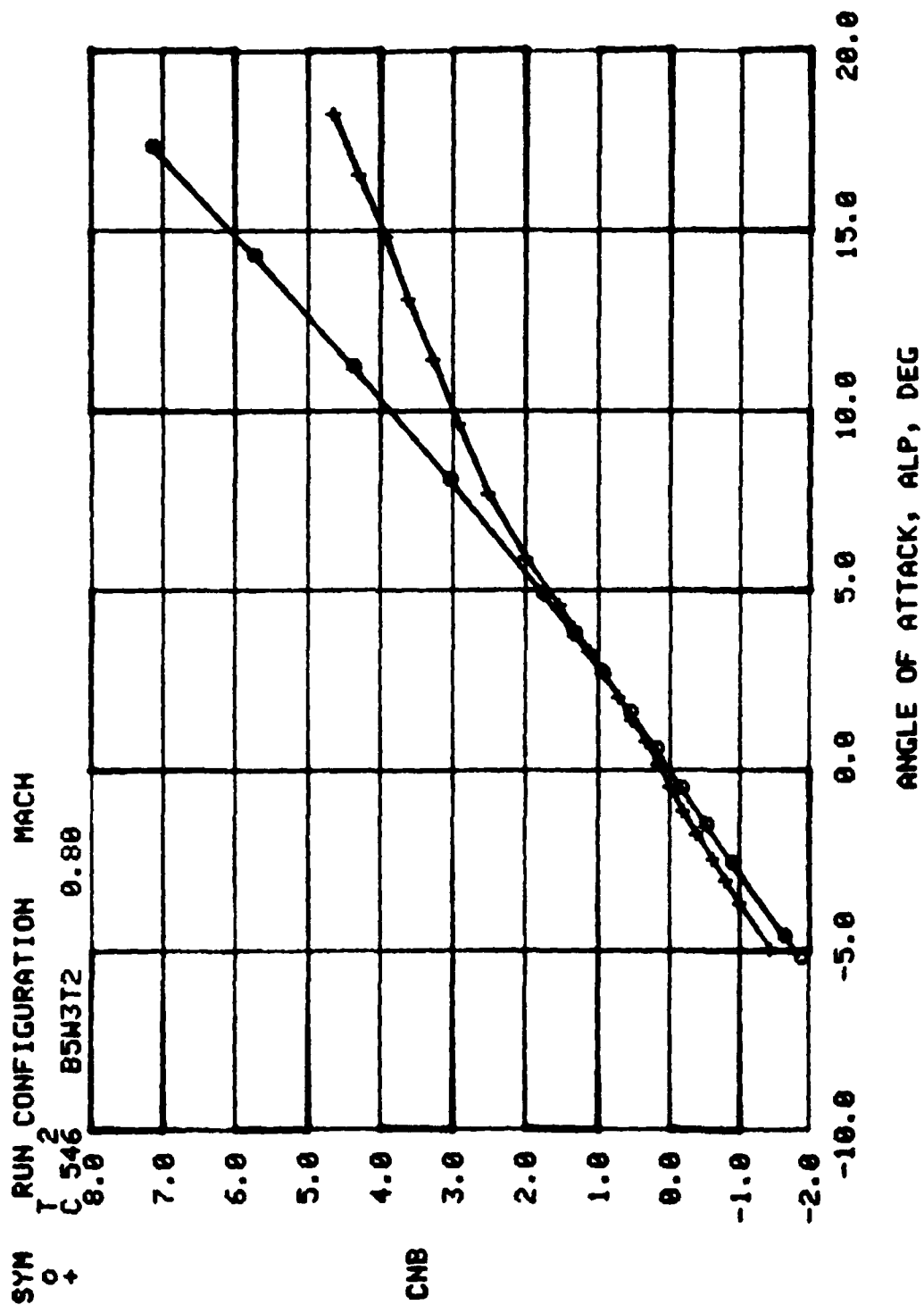
63
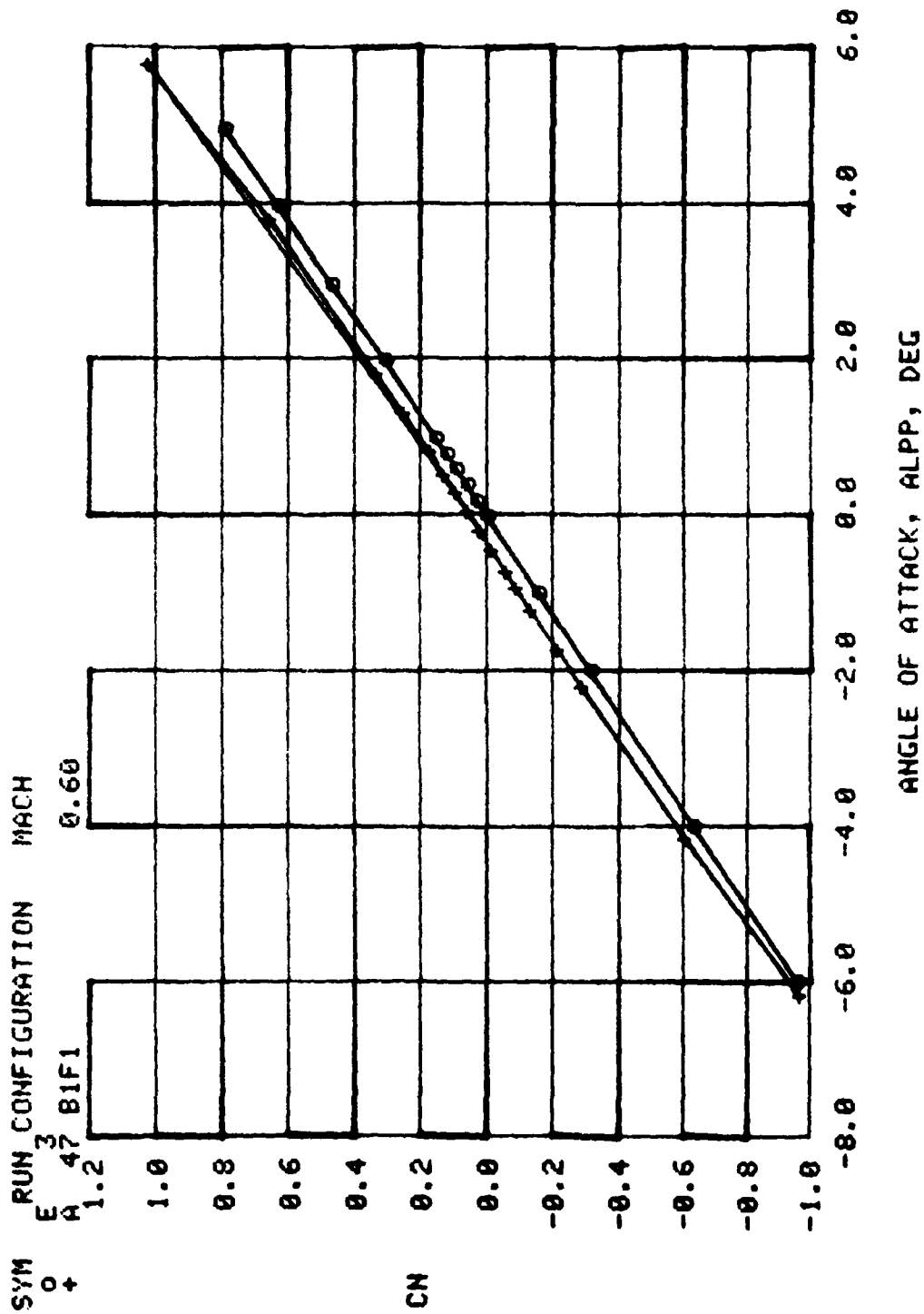
Figure 49. Normal force coefficient vs angle of attack at $M_\infty = 0.6$.
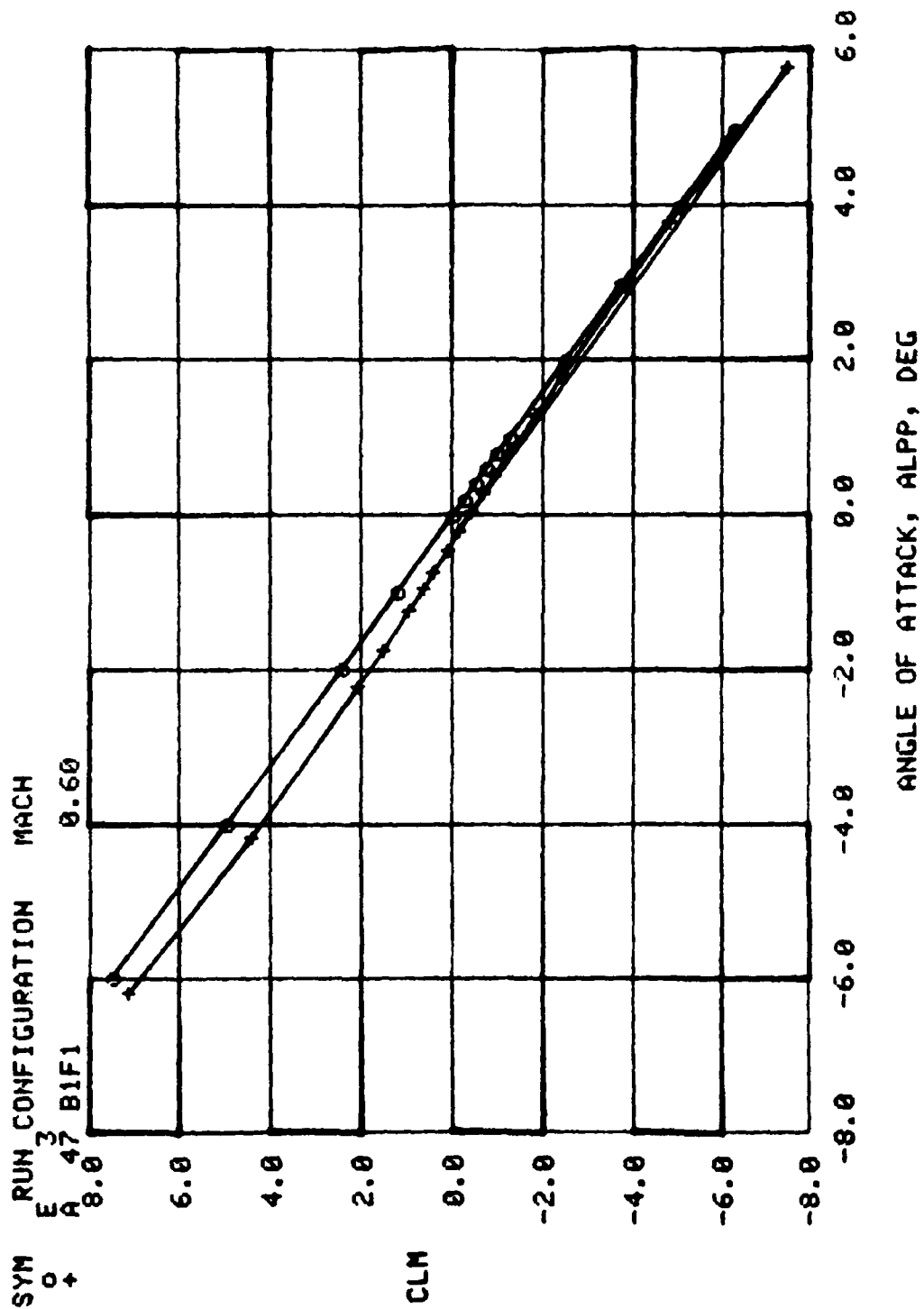
Figure 50. Pitching moment coefficient vs angle of attack at $M_\infty = 0.6$.

65
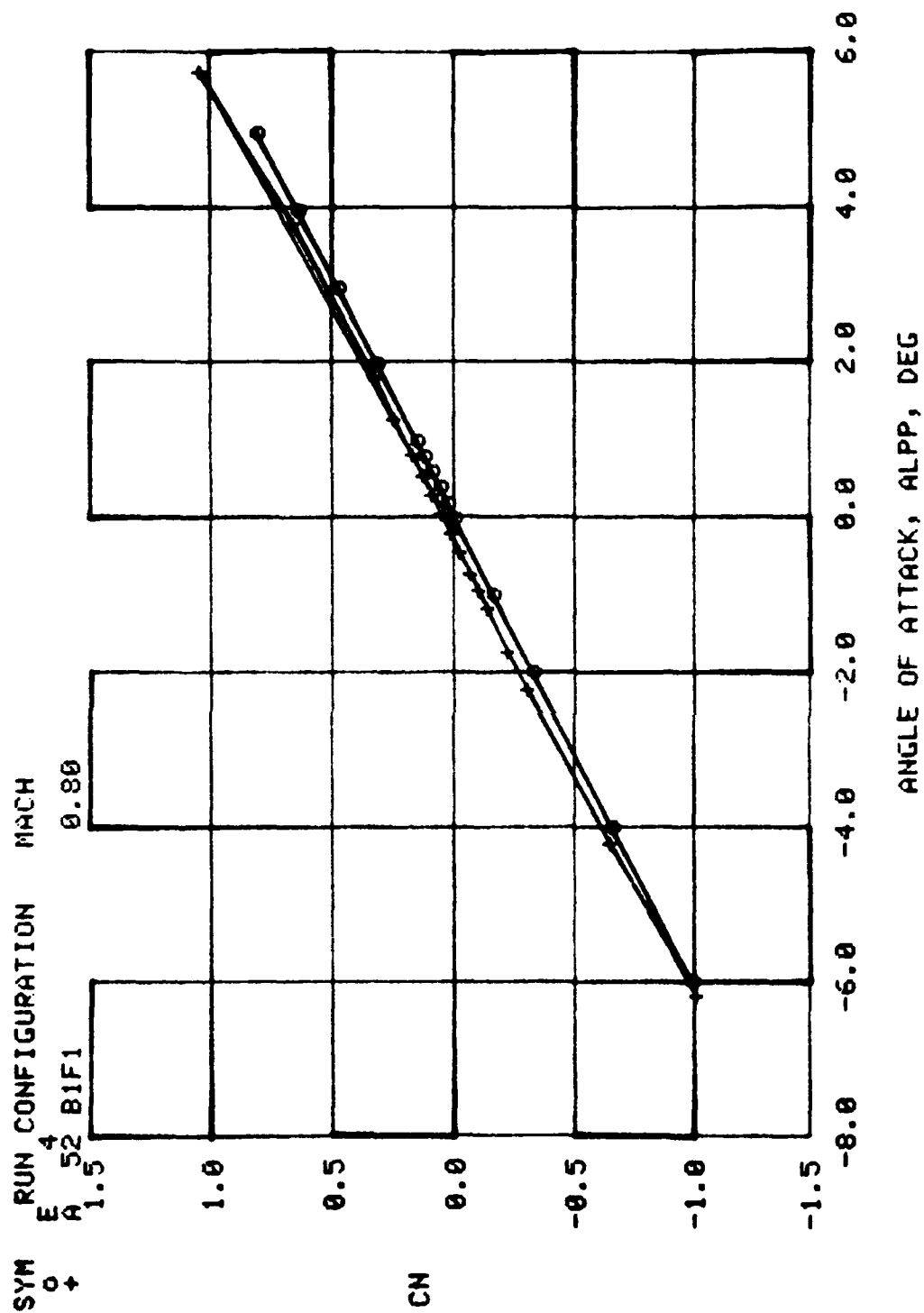
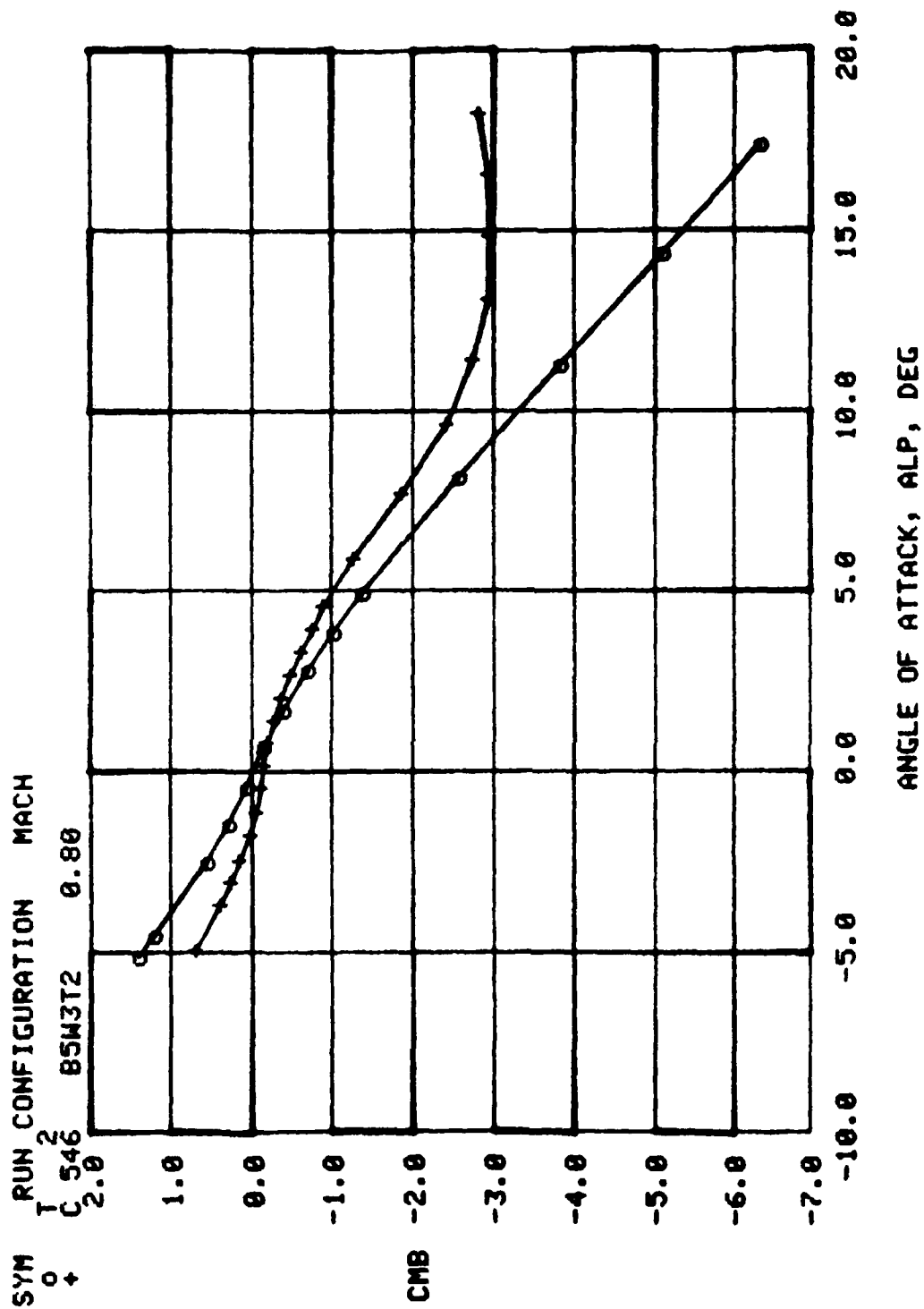Figure 51. Normal force coefficient vs angle of attack at M∞ = 0.8.

66
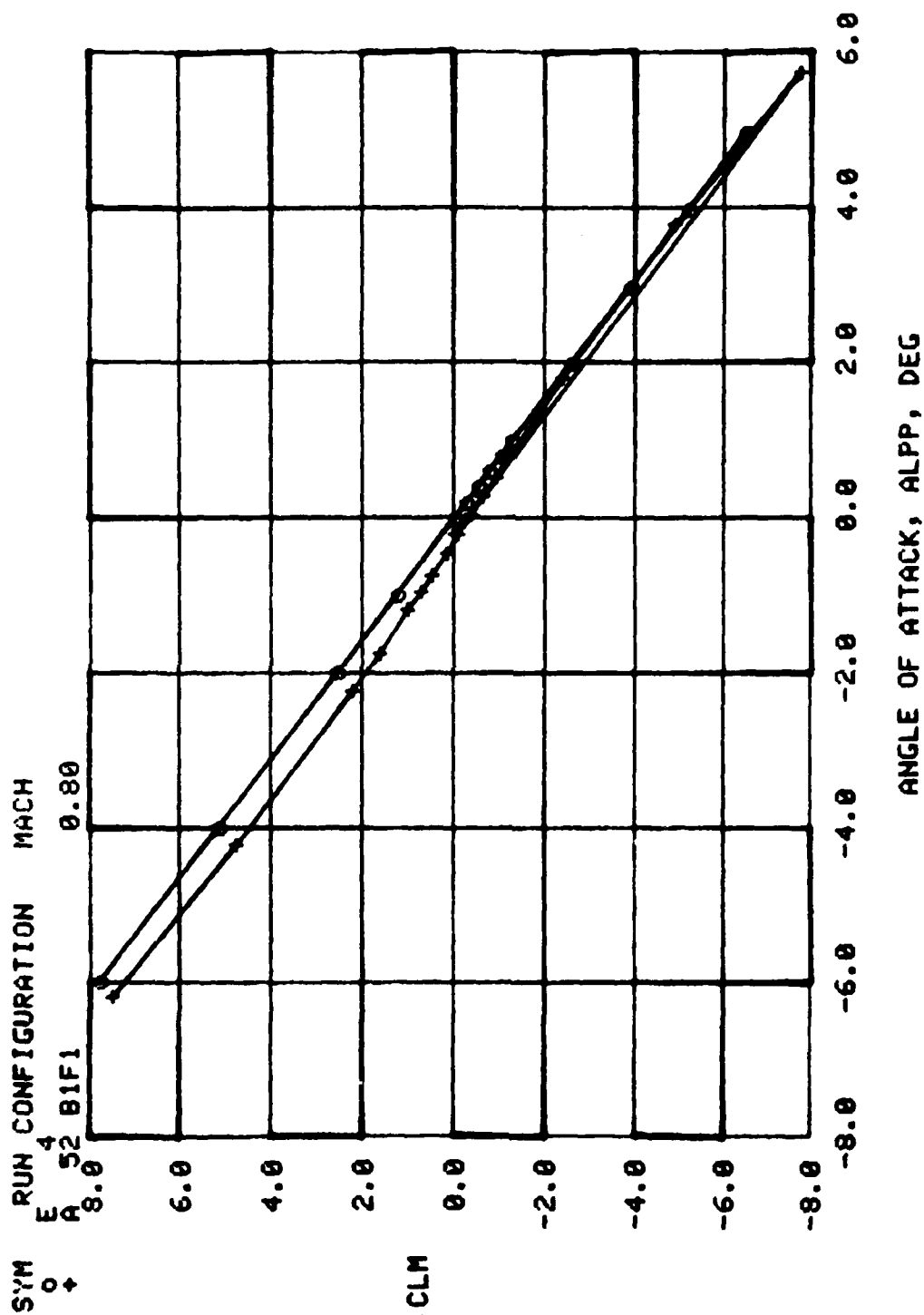
Figure 52. Pitching moment coefficient vs angle of attack at $M_\infty = 0.8$.

67
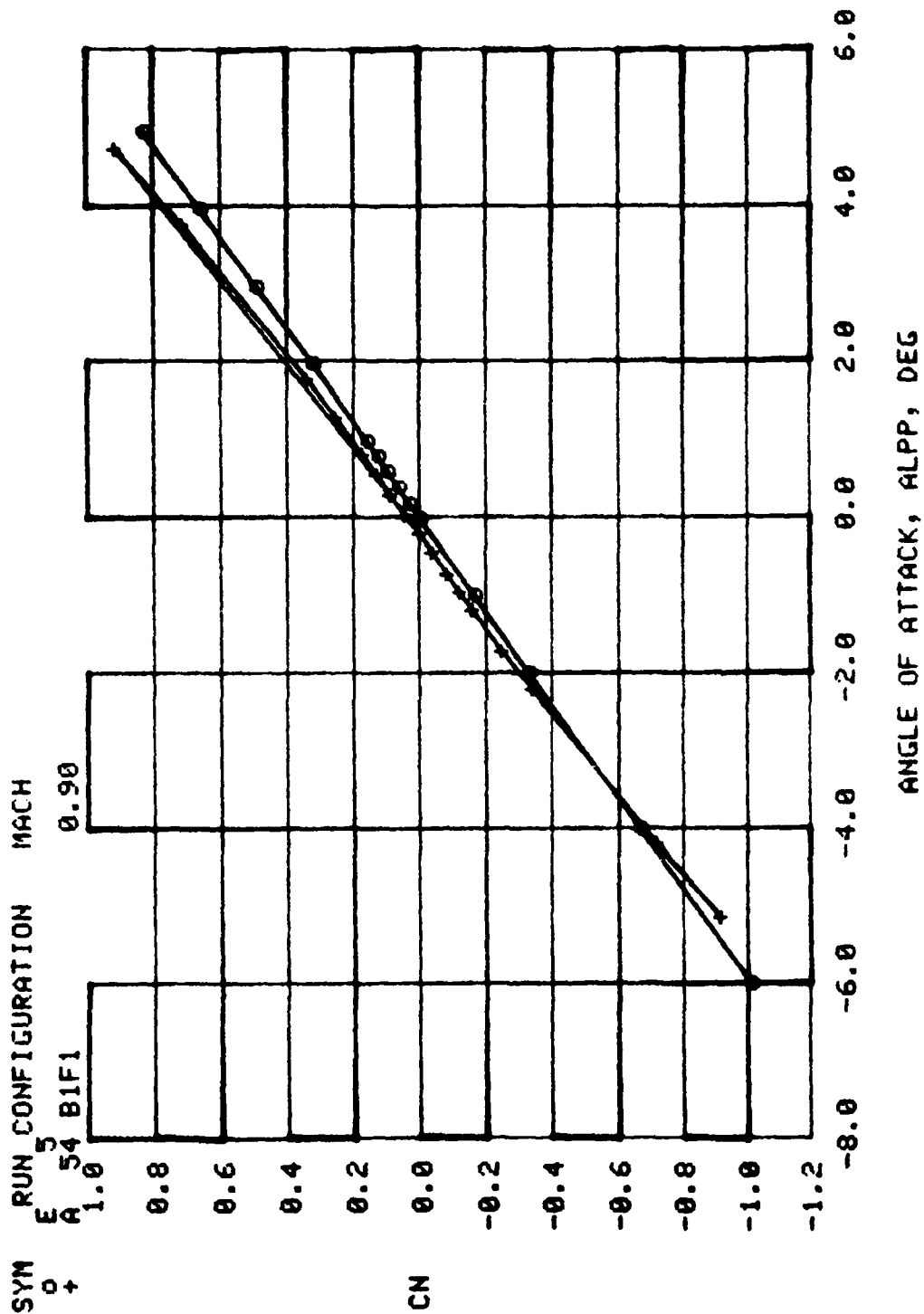
Figure 53. Normal force coefficient vs angle of attack at $M\infty$ = 0.9.
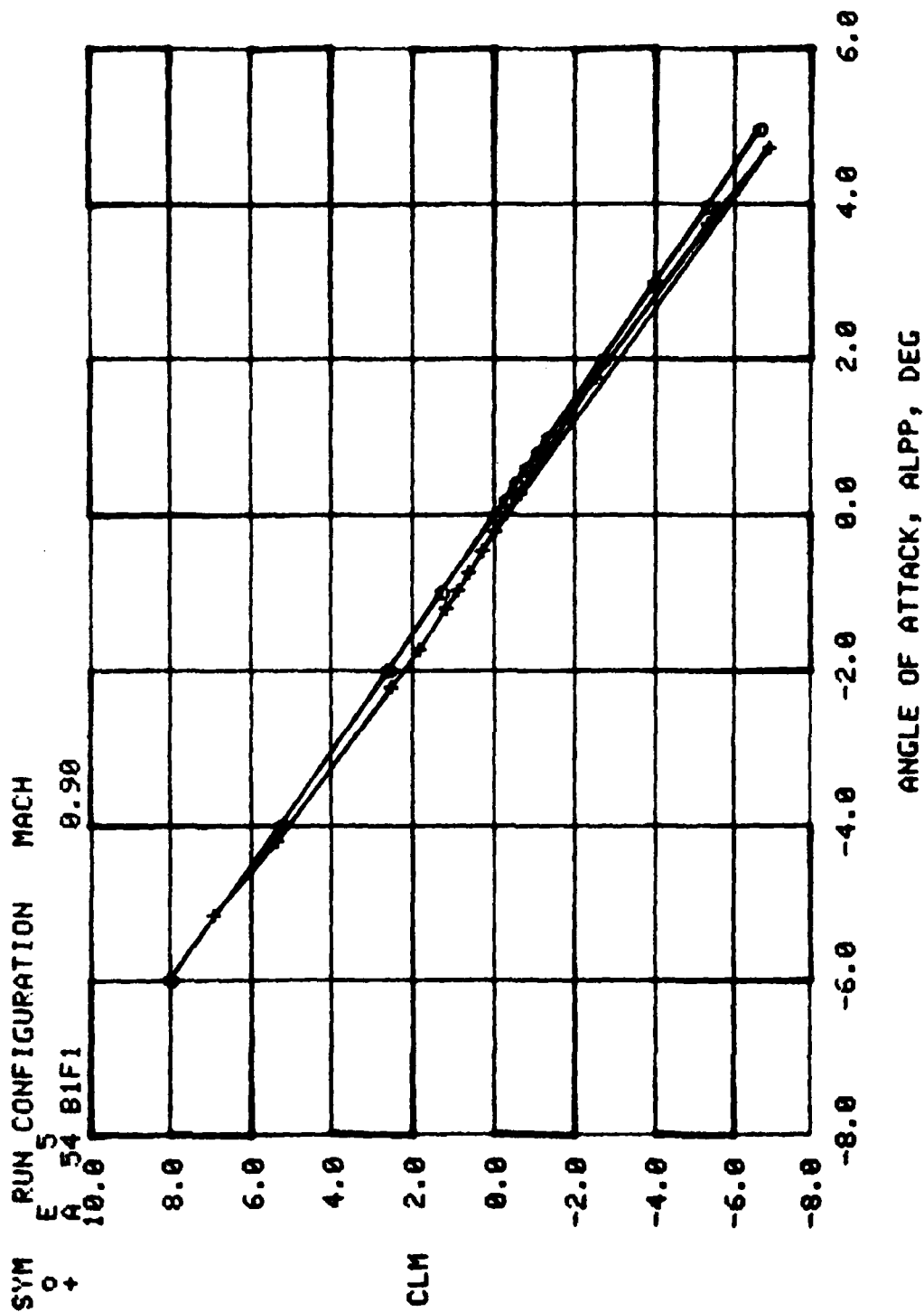
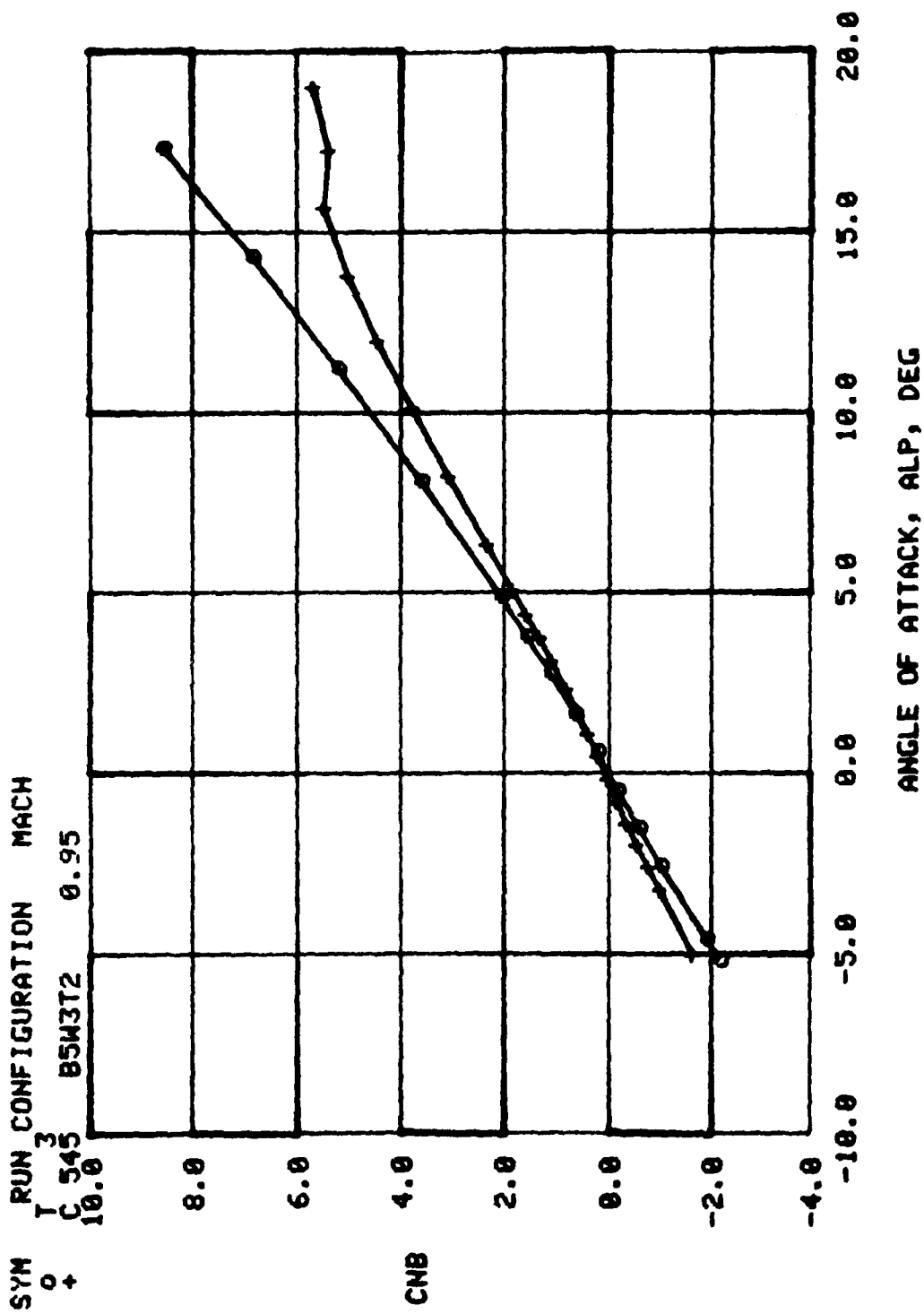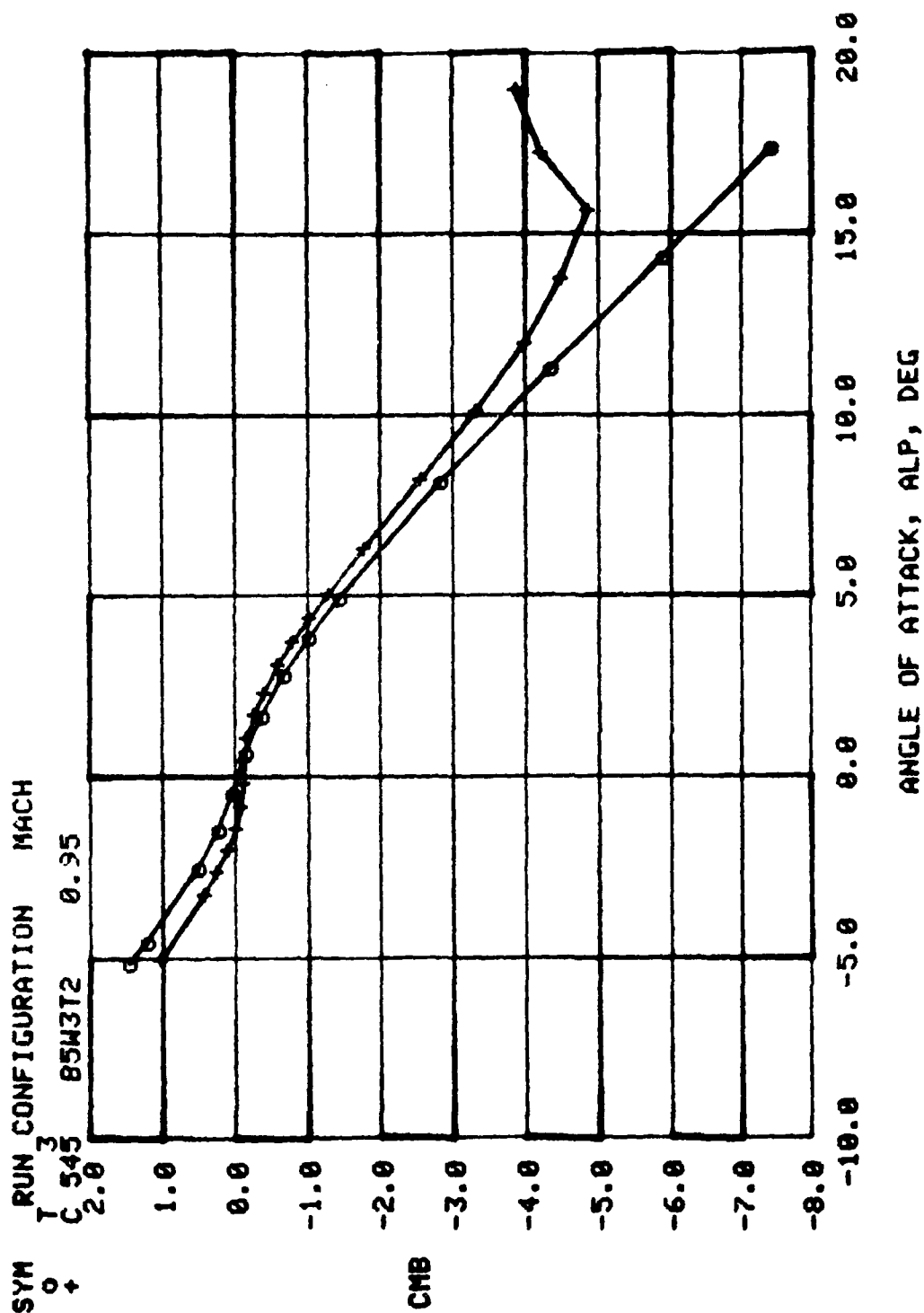Figure 54. Pitching moment coefficient vs angle of attack at $M\infty$ = 0.9.
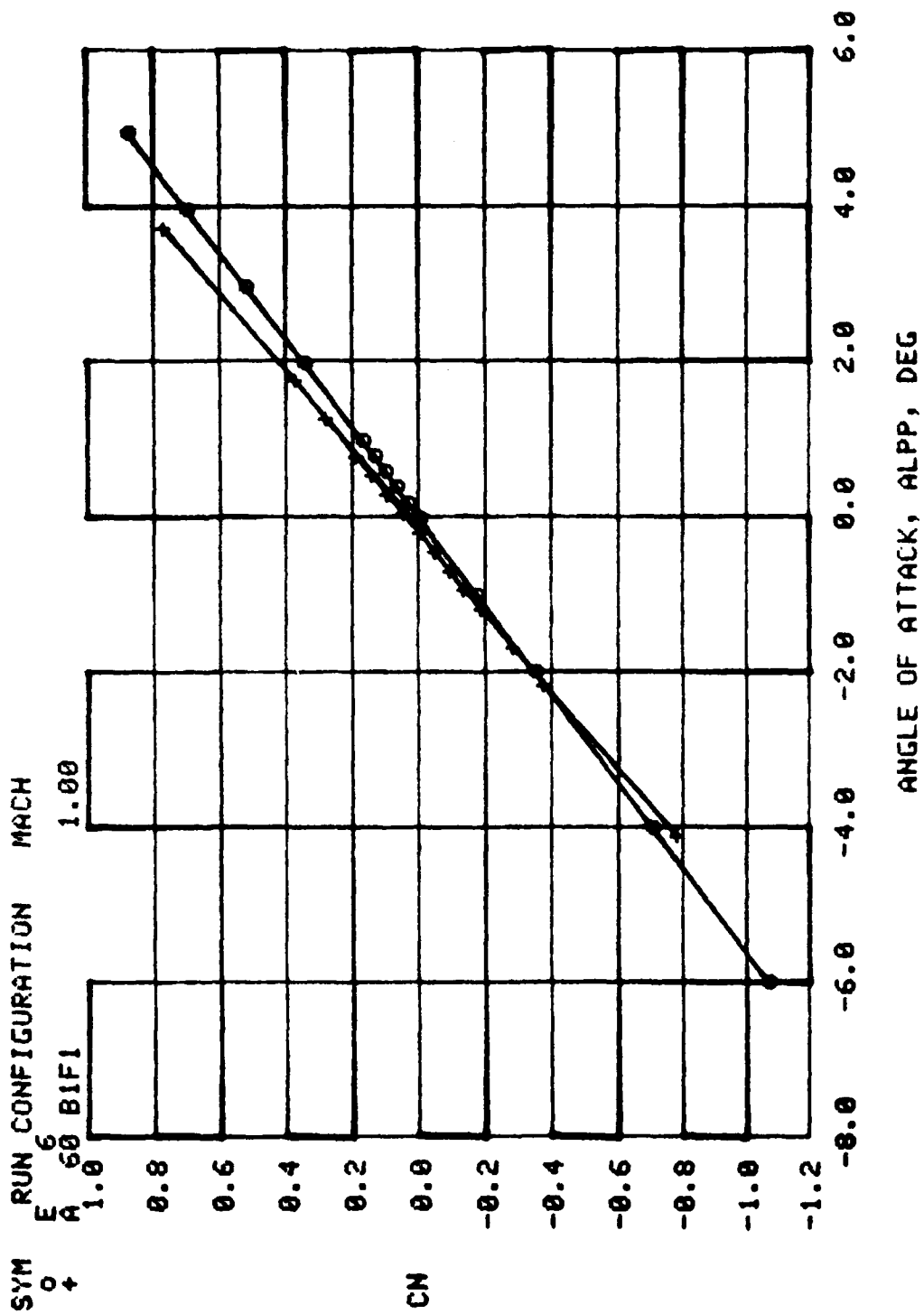
Figure 55. Normal force coefficient vs angle of attack at $M\infty = 1.0$.
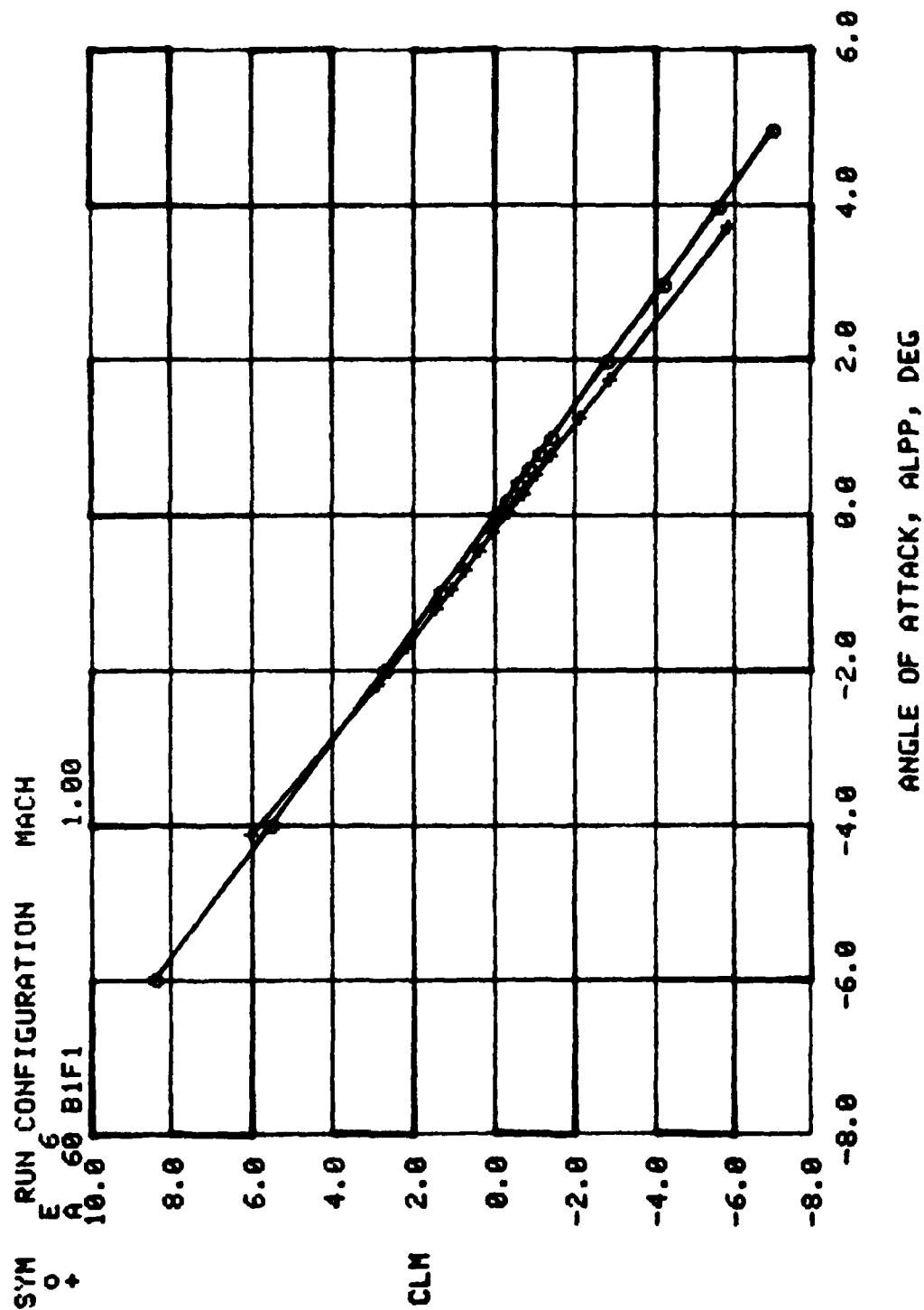
Figure 56. Pitching moment coefficient vs angle of attack at M∞ = 1.0.

71

APPENDIX A

PROGRAM LISTING

SBATCH
PRELIMINARY DESIGN PROGRAM WITH PARAMETERIC VARIATION.
ALL GEOMETERIC VARIABLES MUST HAVE THE SAME SYSTEM OF UNITS.
I.E., CALIBERS, INCHES, ETC. ALL ARE DIVIDED BY DREF WITHIN
THE PROGRAM. THE PROGRAM WORKS IN CALIBERS.
A CALIBER IS DEFINED AS 1 REFERENCE DIAMETER.
INPUT BODY CENTER OF PRESSURE (POSITIVE AFT OF NOSE) - (CAL)
PROGRAM USES BRITISH DATA SHEETS FOR BASIC WING LIFT AND XCP.
PROGRAM USES SLENDER BODY THEORY (NACA 1307) FOR WING-BODY
AND WING-TAIL INTERFERENCE.
....
ALL INPUTS ARE FREE FIELD. INPUTS CAN BE SEPARATED BY A COMMA,
ONE OR MORE BLANKS, OR BY A SLASH (/).
ALL VARIABLES IN AN INPUT LINE MUST HAVE A VALUE TO READ,
I.E., 0. FREE FIELD READ WILL NOT INTERPRET BLANKS AS ZERO'S.

.... INPUT 1

TITLE CARD (1-80 CHARACTERS)

.... INPUT 2

NWPOS   = 1   INPUT XWING AS STATION OF WING LEADING EDGE
  "   = 2   PROGRAM WILL MOVE WING 1/4 CHORD TO WING HINGE LINE
  "   = 3   PROGRAM WILL MOVE WING 1/2 CHORD TO WING HINGE LINE
  "   = 4   INPUT XWING AS STATION OF WING TRAILING EDGE.
NTPOS   = 1   INPUT XTAIL AS STATION OF TAIL LEADING EDGE
  "   = 2   PROGRAM WILL MOVE TAIL 1/4 CHORD TO TAIL HINGE LINE
  "   = 3   PROGRAM WILL MOVE TAIL 1/2 CHORD TO TAIL HINGE LINE
  "   = 4   INPUT XTAIL AS STATION OF TAIL TRAILING EDGE.
MCDVT   = 1 NO EFFECT.
  "   = 2 USE NACA REPT. 1253 (MCDEVITT) FOR FIN ALONE CLA.
          GOOD FOR RECTANGULAR FINS ONLY.
          GOOD FOR MACH NUMBERS BELOW 1.1 ONLY.
NOUT   = 1 TRIM OUTPUT ONLY.
        = 2 ALPHA OUTPUT ONLY.
        = 3 TRIM AND ALPHA OUTPUT.
NRUN   =   INITIAL RUN NUMBER. - 1 TO 4 DIGITS.
NDBASE = 1 NO EFFECT.
        = 2 OUTPUT DATA BASE FILE.

.... INPUT 3

NOSE   = 1 OGIVE NOSE
  "   = 2 CONICAL NOSE
XLN   = NOSE LENGTH
XL   = TOTAL LENGTH

.... INPUT 4

RBW   = RADIUS OF BODY AT WING
RBT   = RADIUS OF BODY AT TAIL
DREF   = REFERENCE LENGTH
AREF   = REFERENCE AREA
DREFFT = REFERENCE LENGTH - FT.
AREFFT = REFERENCE AREA IN SQ. FT.
YIY   = TRANSVERSE MOMENT OF INERTIA - SLUG-FT2.

.... INPUT 5

NBODY   = NUMBER OF POINTS FOR BODY ALONE CNACY AND XCPCY
      (IF NBODY=0, OMIT INPUTS 6. PROGRAM WILL COMPUTE SLOPE DATA.)

.... INPUTS 6

I=ACH   = TABLE OF MACH NUMBERS FOR CNACY AND XCPCY
ICNACY   = TABLE OF BODY ALONE NORMAL FORCE COEFF SLOPES (BASED ON
            BODY CROSS SECTIONAL REFERENCE AREA) - 1/RAD
IXCPCY   = TABLE OF BODY ALONE CENTER OF PRESSURE - CAL FROM NOSE.

.... INPUT 7

NBTL=0   PROGRAM WILL NOT ADD BOATTAIL CNA AND XCP.
"   =1   PROGRAM USES BOATTAL CARDS TO CALCULATE BOATTAIL EFECTS
DBOD = DIAMETER RATIO (BOATTAIL/CYLINDER)
XLBOD = RATIO (BOATTAIL LENGTH/CYLINDER DIAMETER)

.... INPUT 8

NMF   = NUMBER OF POINTS FOR XCG VS MACH NUMBER

.... INPUTS 9

TMF   = TABLE OF MACH NUMBERS FOR XCG
IXCG   = TABLE OF CENTER OF GRAVITY - CALIBERS FROM NOSE.
IWEIGH   = TABLE OF WEIGHT - LBS.

.... INPUT 10

NFMA   = NUMBER OF FREE STREAM MACH NUMBERS

.... INPUTS 11

TFMA   = TABLE OF FREE STREAM MACH NUMBERS
IALT   = ALTITUDE FOR EACH MACH NO. - FT ABOVE SEA LEVEL
TRE   = REYNOLDS NUMBER FOR EACH MACH NO. - MILLIONS/FT.
            NOTE: PROGRAM MULTIPLIES TRE BY 1 MILLION TO GET RE.

.... INPUTS 12-26

TBOW   = TABLE OF WING EXPOSED SEMI-SPANS(LOAD 0. IF NO WING)
ICRW   = TABLE OF WING ROOT CHORDS
TTRW   = TABLE OF WING TAPER RATIOS(CT/CR)
TSWTEW   = TABLE OF WING TRAILING EDGE SWEEP ANGLES(DEG)
TXWING   = TABLE OF WING STATIONS (MEASURED FROM NOSE) (SEE NWPOS)
THINGW   = TABLE OF WING HINGE LINES
TBOT   = TABLE OF TAIL EXPOSED SEMI-SPANS(LOAD   0. IF NO TAIL)
TCRT   = TABLE OF TAIL ROOT CHORDS
TTRT   = TABLE OF TAIL TAPER RATIOS (CT/CR)
TSWTET   = TABLE OF TAIL TRAILING EDGE SWEEP ANGLES (DEG)
TXTAIL   = TABLE OF TAIL POSITIONS (MEASURED FROM NOSE)
THINGT   = TABLE OF TAIL HINGE LINES
"   = 0. (PROGRAM SETS HINGT=1/4 MEAN AERODYNAMIC CHORD)
TDELT   = TABLE OF TAIL DEFLECTIONS - DEG.
TDELW   = TABLE OF WING DEFLECTIONS - DEG.
TALP   = TABLE OF ANGLES OF ATTACK - DEG.

.... INPUTS 27-29   (USED ONLY IF NOBASE=2)

IC(1)   = FIRST PACKED WORD FOR COEFFICIENTS.
IC(2)   = SECOND PACKED WORD FOR COEFFICIENTS.
IP   = PACKED WORD FOR PARAMETERS.
          (SEE DATA BASE INSTRUCTIONS FOR DEFINITION
           OF PACKED WORDS)

76

```
........................................................
DIMENSION TMF(15),TXCG(15),TMACH(15),TCNACY(15),TXCPCY(15)
DIMENSIONTFMA(16),TCRW(16),TTRW(16),TBOW(16),TSWTEW(16),TXWING(16)
DIMENSION         TCRT(16),TTRT(16),TBOT(16),TSWTET(16),TXTAIL(16)
DIMENSION THINGW(16),THINGT(16)
DIMENSION TRE(16),TALT(16),TDELT(10),TDELW(10),TALP(20),TWEIGH(15)
DIMENSION IFILE(3),TITLE(20),HOL(10)
DIMENSION ACON(3),H(32),Y(25,3)

COMMON /BODY/ XL,XLN,RE,DREFF1,DCY,ACY,AREF,NOSE,CNAB,XCPB
COMMON /WING/ BOW,RBW,CRW,XWING,XCENW,PHIW,HINGW,AWAR,ARW
COMMON /WING2/ CLAW,XCPW,BKWB,BKBW,SKWB,SKBW
COMMON /TAIL/ BOT,RBT,TR1,XTAIL,XCENT,PHIT,HINGT,ATAR,ART
COMMON /TAIL2/ CLAT,XCPT,BKTB,BKBT,SKTB,SKBT
COMMON /PARTS/ CNBY,XCPBY,CNW,XCPWN,CNT,XCPTL,CLTV


REAL   LABEL
102     FORMAT (2F10.4)
103     FORMAT (3F10.4)
108     FORMAT (8F10.4)
109     FORMAT (13I2)
110     FORMAT (I2,8X,3F10.4)
111     FORMAT (20A4)
112     FORMAT (2I2,6X,3F10.4)
198     FORMAT (1H )
199     FORMAT (1H1)
200     FORMAT (1H1,'INPUT TABLES'/)
202     FORMAT (1H ,2F10.4)
203     FORMAT (1H ,3F10.4)
209     FORMAT (1H0,20A4)
210     FORMAT (1H0,'GEOMETERIC VARIABLES'30X'BODY'6X'WING'6X,'TAIL'/)
211     FORMAT (1H ,'CR         ROOT CHORD'                    36X2F10.4)
212     FORMAT (1H ,'CT         TIP CHORD'                     37X2F10.4)
213     FORMAT (1H ,'BO         EXPOSED SEMI-SPAN'             29X2F10.4)
214     FORMAT (1H ,'AR         ASPECT RATIO'                  34X2F10.4)
215     FORMAT (1H ,'TR         TAPER RATIO'                   35X2F10.4)
216     FORMAT (1H ,'SWLE       LEADING EDGE SWEEP ANGLE (DEG)' 16X2F10.4)
217     FORMAT (1H ,'SWTE       TRAILING EDGE SWEEP ANGLE (DEG)' 15X2F10.4)
218     FORMAT (1H ,'CBAR/CR    MEAN GEOMETERIC CHORD/CR'      22X2F10.4)
219     FORMAT (1H ,'YBAR/BO    SPANWISE LOCATION OF CBAR'     21X2F10.4)
220     FORMAT (1H ,'XM/CR      CHORDWISE LOCATION OF CBAR'    20X2F10.4)
221     FORMAT (1H ,'CENT/CR    DIST. FROM L.E. CR TO CENTROID' 16X2F10.4)
222     FORMAT (1H ,'RB         RADIUS OF BODY AT FIN'         25X2F10.4)
223     FORMAT (1H ,'XFIN       DIST. FROM NOSE TO L.E. CR'    20X2F10.4)
224     FORMAT (1H ,'XCENT      DIST. FROM NOSE TO CENTROID'   19X2F10.4)
225     FORMAT (1H ,'A/AR       AREA RATIO (2 FINS/AREF)'      22X2F10.4)
226     FORMAT (1H ,'HINGE      DIST. FROM NOSE TO HINGE'      22X2F10.4)
227     FORMAT (1H ,'PHI        FIN ROLL ANGLE (DEG)'          26X2F10.4)
230     FORMAT (1H ,'XL         BODY LENGTH'                   24XF10.4)
231     FORMAT (1H ,'DREF       REFERENCE LENGTH  '            17XF10.4)
232     FORMAT (1H ,'AREF       REFERENCE AREA         '       10XF12.4)
2322    FORMAT (1H ,'DREFFT     REFERENCE LENGTH-FT.'          15XF10.4)
2323    FORMAT (1H ,'AREFFT     REFERENCE AREA FT**2'          15XF10.4)
233     FORMAT (1H ,'YIY        MOMENT OF INERTIA'             18XF10.4)
234     FORMAT (1H ,'DBOD       BOATTAIL DIA. (CAL.)'          15XF10.4)
235     FORMAT (1H ,'XLBOD      BOATTAIL LENGTH (CAL.)'        13XF10.4)
236     FORMAT (1H ,'DCYODR     RATIO (CYL. DIA/REF. DIA)'     10XF10.4)
301     FORMAT (1H0'PROBLEM WITH INPUT DATA FILE-(TAPE5),  STATUS='I4/)
302     FORMAT (1H0'WARNING: TAPE5 NOT CLOSED'/)
400     FORMAT (1H0,11X,'BKUP',5X,'BKCO',5X,'CLA',5X,'CP',8X,
+ 'CNA',6X,'XCP',5X,'CMACG',5X,'CMO',6X,'CLP',6X,'CLD',
+ 6X,'CMA',6X,'CMD',6X,'CND',5X,'CMDCG')
401     FORMAT (1X,'BODY ',36X,4F9.3)
```
77

```
402     FORMAT (1X,'WING ',14F9.3)
403     FORMAT (1X,'TAIL ',14F9.3)
404     FORMAT (1X,'TOTAL',36X,5F9.3)
4444    FORMAT (1X,'SIGMA ',F9.3)
4040    FORMAT (" ",T43,46("*"),/,T43,"*",T88,"*",/,
+   T43,"*",T58,"FLIGHT CONDITIONS",T88,"*",/,T43,"*",T88,"*"
+   ,/,T43,46("*"))
4041    FORMAT (1H0," ",T44,46("*"),/,T43,"*",T88,"*",/,
+   T43,"*",T52,"ANGLE OF ATTACK DATA (SLOPES)",T88,"*",/,T43,"*",T88,"*",/,
+   T43,"*",T88,"*",/,T43,46("*"))
4042    FORMAT (" ",T43,46("*"),/,T43,"*",T88,"*",/,T43,"*",T88,"*",/,
+   T43,"*",T61,"TRIM POINT",T88,"*",/,T43,"*",T88,"*",/,
+   T43,"*",T88,"*",/,T43,46("*"))
4043    FORMAT (1H0," ",T44,46("*"),/,T43,"*",T88,"*",/,T43,"*",T88,"*",/,
+   T43,"*",T55,"ANGLE OF ATTACK SWEEP",T88,"*",/,T43,"*",T88,"*",/,
+   T43,"*",T88,"*",/,T43,46("*"))
410     FORMAT (1H0,'FMACH=',F9.3,2X,'XCG=',F9.3,2X,'WEIGHT=',F9.3,
+   2X,'ALT=',F9.3,2X,'RE=',F10.0)
450     FORMAT (1H0,3X,'ALPHA',4X,'DELW',4X,'DELT',6X,'CN',6X,
+   'XCP',6X,'CMCG',5X,'HMW',6X,'HMT',5X,'FTRAT',1X,'GLOAD')
451     FORMAT (1H ,1F8.2,3F9.3,10F8.3)
452     FORMAT (1H0,'NO TRIM AFTER ',I3,2X,'ITERATIONS FOR DELW=',
+   F7.3,3X,'DELT=',F7.3)
453     FORMAT (1H0,3X,'ALPHA',6X,'CN',6X,
+   'XCP',6X,'CMCG',6X,'CHW',5X,'CHT',3X,'FTRAT',4X,
+   'CNB',4X,'XCPB',5X,'CNW',4X,'XCPW',5X,'CNT',4X,'XCPT',4X,'CNTV')
454     FORMAT (1H0,'TRIM POINT')
455     FORMAT (1H0,'NO TRIM BELOW ALP=',F7.3,2X,'FOR DELW=',F7.3,
+   2X,'AND DELT=',F7.3)
456     FORMAT (1H0,'RUN NUMBER',I4)
990     FORMAT (1H0,'TYPE INPUT FILE NAME - 1 TO 12 CHARACTERS')
991     FORMAT (3A4)
995     FORMAT (1H1,'CONFIGURATION'I4)
----------------------------------------
1       WRITE (1,990)
READ (1,991) IFILE
CALL CLOSE (5,ISTA)
CALL OPENW (5,IFILE,1,0,0,ISTA)
IF (ISTA.EQ.0) GO TO 8
WRITE (1,301) ISTA
PAUSE
GO TO 1
8       NCONF=0
READ (5,111) TITLE
READ (5,*) NWPOS,NTPOS,MCDVT,NOUT,NRUN,NDBASE
READ (5,*) NOSE,XLN,XL
READ (5,*) RBW,RBT,DREF,AREF,DREFFT,AREFFT,YIY
READ (5,*) NBODY
IF (NBODY.EQ.0) GO TO 4
READ (5,*) (TMACH(I),TCNACY(I),TXCPCY(I), I=1,NBODY)
4       READ (5,*) NBTL,DBOD,XLBOD
READ (5,*) NMF
READ (5,*) (TMF(I),TXCG(I),TWEIGH(I), I=1,NMF)
READ (5,*) NFMA
READ (5,*) (TFMA(I),TALT(I),TRE(I), I=1,NFMA)
CALL READX (5,80,HOL,TBOW,NH,NBOW,EOFF)
CALL READX (5,80,HOL,TCRW,NH,NCRW,EOFF)
CALL READX (5,80,HOL,TTRW,NH,NTRW,EOFF)
CALL READX (5,80,HOL,TSWTEW,NH,NSWW,EOFF)
CALL READX (5,80,HOL,TXWING,NH,NXWING,EOFF)
CALL READX (5,80,HOL,THINGW,NH,NHINGW,EOFF)
CALL READX (5,80,HOL,TBOT,NH,NBOT,EOFF)
CALL READX (5,80,HOL,TCRT,NH,NCRT,EOFF)
```
78

```
      CALL READX (5,80,HOL,TTRT,NH,NTRT,EOFF)
      CALL READX (5,80,HOL,TSWTET,NH,NSWT,EOFF)
      CALL READX (5,80,HOL,TXTAIL,NH,NXTAIL,EOFF)
      CALL READX (5,80,HOL,THINGT,NH,NHINGT,EOFF)
      CALL READX (5,80,HOL,TDELT,NH,NDELT,EOFF)
      CALL READX (5,80,HOL,TDELW,NH,NDELW,EOFF)
      CALL READX (5,80,HOL,TALP,NH,NALP,EOFF)

      IF (NOBASE.EQ.2) CALL DATA1
      CALL CLOSE (5,ISTA)
      IF (ISTA.NE.0) WRITE (1,302)
C..............................         WRITE INPUT TABLES
      WRITE (6,200)
      IF(NBODY.EQ.0) GO TO 2
      WRITE (6,203) (TMACH(I),TCNACY(I),TXCPCY(I), I=1,NBODY)
2     WRITE (6,198)
      WRITE (6,203) (TMF(I),TXCG(I),TWEIGH(I), I=1,NMF)


      PI=3.14159
      RAD=57.29578
      SMALL=1.E-30
      PHIW=0.0
      PHIT=0.0
      DCY=2.*RBT
      DCYODR=DCY/DREF
      ACY=(PI/4)*DCY**2
C..............................................
      DO 90 I2=1,NCRW
      CRW=TCRW(I2)
      DO 90 I3=1,NTRW
      TRW=TTRW(I3)
      DO 90 I4=1,NBOW
      BOW=TBOW(I4)
      DO 90 I5=1,NSWW
      SWTEW=TSWTEW(I5)
      DO 90 I6=1,NXWING
      XWING=TXWING(I6)
      DO 90 I12=1,NHINGW
      HINGW=THINGW(I12)
C..............................................    CALCULATE WING GEOMETRY
      CALL HULL (BOW,CRW,TRW,RBW,DREF,AREF,CLPW1,CLDW1)
      CALL FINGEOM (CRW,TRW,BOW,AREF,SWTEW,CTW,ARW,SWLEW,CBARW,YBARW,
     +  XMW,CENTW,AFAR,TANLW,SWHAW)
      AWAR=2.*AFAR
      IF(NWPOS.EQ.2) XWING=HINGW-(.25*CBARW+XMW)*CRW
      IF(NWPOS.EQ.3) XWING=HINGW-(.50*CBARW+XMW)*CRW
      IF(NWPOS.EQ.4) XWING=XWING - CRW
      XCENW=(CENTW*CRW+XWING)
C..............................................
      DO 90 I7=1,NCRT
      CRT=TCRT(I7)
      DO 90 I8=1,NTRT
      TRT=TTRT(I8)
      DO 90 I9=1,NBOT
      BOT=TBOT(I9)
      DO 90 I10=1,NSWT
      SWTET=TSWTET(I10)
      DO 90 I11=1,NXTAIL
      XTAIL=TXTAIL(I11)
      DO 90 I13=1,NHINGT
      HINGT=THINGT(I13)
C..............................................    CALCULATE TAIL GEOMETRY
```
79

```
      CALL ROLL (BUT,CRT,TRT,RBT,DREF,AREF,CLPT1,CLOT1)
      CALL FINGEOM (CRT,TRT,BUT,AREF,SWTET,CTT,ART,SWLET,CBART,YBART,
     +  XMT,CENTT,AFAR,TANLT,SWHAT)
      ATAR=2.*AFAR
      IF(NTPOS.EQ.2) XTAIL=HINGT-(.25*CBART+XMT)*CRT
      IF(NTPOS.EQ.3) XTAIL=HINGT-(.50*CBART+XMT)*CRT
      IF(NTPOS.EQ.4) XTAIL=XTAIL - CRT
      XCENT=(CENTT*CRT+XTAIL)
      IF(HINGT.EQ.0.) HINGT=XTAIL + (XMT + .25*CBART)*CRT
      ...........................          GEOMETRY OUTPUT
      NCONF=NCONF + 1
      WRITE (6,995) NCONF
      WRITE (6,209) TITLE
      WRITE (6,210)
      WRITE (6,230) XL
      WRITE (6,231) DREF
      WRITE (6,232) AREF
      WRITE (6,2322) DREFFT
      WRITE (6,2323) AREFFT
      WRITE (6,233) YII
      IF (NBTL.EQ.0) GO TO 5
      WRITE (6,234) DBOD
      WRITE (6,235) XLBOD
      WRITE (6,236) DCYODR
5     WRITE (6,213) TBUW(I4),TBUT(I9)
      WRITE (6,211) TCRW(I2),TCRT(I7)
      WRITE (6,212) CIW,CIT
      WRITE (6,215) TRW,TRT
      WRITE (6,214) ARW,ART
      WRITE (6,216) SWLEW,SWLET
      WRITE (6,217) SWTEW,SWTET
      WRITE (6,218) CBARW,CBART
      WRITE (6,219) YBARW,YBART
      WRITE (6,220) XMW,XMT
      WRITE (6,221) CENTW,CENTT
      WRITE (6,222) RBW,RBT
      WRITE (6,223) XWING,XTAIL
      WRITE (6,224) XCENW,XCENT
      WRITE (6,225) AWAR,ATAR
      WRITE (6,226) HINGW,HINGT
      WRITE (6,227) PHIW,PHIT
      ...........................          START MACH NUMBER LOOP
      DO 91 II=1,NFMA
      FMACH=TFMA(II)
      ALT=TALT(II)
      RE=TRE(II)*1.E6
      CALL STAN62 (ALT,CS,RHO,PRESS,TEMP,2)
      Q=(.7*PRESS*FMACH**2)
      BETA=SQRT(ABS(FMACH**2-1.))
      CALL INTERP (2,1,XCG,TXCG,FMACH,TMF,NMF,2,MIN,MAX)
      CALL INTERP (2,1,WEIGHT,TWEIGH,FMACH,TMF,NMF,2,MIN,MAX)
      XCG=XCG*DCY
      IF (WEIGHT.EQ.0.) WEIGHT=1.
      ...........................................

      START ZERO ALPHA LOOP  -  SLOPES

      ...........................          BODY FORCE COEFF.
      IF (NBODY.NE.0) GO TO 7
      XLA=XL - XLN
      XLN2=XLN/DCY
      XLA2=XLA/DCY
      CALL BODY (NOSE,XLN2,XLA2,FMACH,CNACY,XCPCY)
```
80

```
      GO TO 3
7        CALL INTERP (2,1,CNACY,TCNACY,FMACH,TMACH,NBODY,3,MIN,MAX)
      CALL INTERP (2,1,XCPCY,IXCPCY,FMACH,TMACH,NBODY,3,MIN,MAX)
3        CONTINUE
      XCPCY=XCPCI*DCY
      CNACY=CNACI*ACY/AREF
      CNABT=0.
      XCPBT=0.
      IF (NBTL.EQ.0) GO TO 6
      CALL BOATL (FMACH,DBOD,XLBOD,CNABT,XCPBT)
      XCPBT=XCPBT*DCYODR*DREF + XL - XLBOD*DCYODR*DREF
      CNABT=CNABI*ACY/AREF
6        CNAB=CNACY + CNABT
      CMAB=(CNACY*XCPCY + CNABI*XCPBT)/DREF
      XCPB=CMAB*DREF/(CNAB + SMALL)
      ARMCY=(XCG-XCPCI)/DREF
      ARMBI=(XCG-XCPBT)/DREF
      CMQB=-2.*(CNACY*ARMCY**2 + CNABI*ARMBI**2)
      CMACGB=CNACY*ARMCI + CNABT*ARMBT
      ............................    WING FORCE COEFF.
      FW=0.
      XCPW=0.
      CMQW=0.
      CMACGW=0.
      CLPW=0.
      IF(BOW.EQ.0.0) GO TO 561
      CALL BRIT (FMACH,ARW,TRW,SWHAW,CLAW,CPCB)
      CPW=CPCB*CBARW + XW
      IF((MCDVT.EQ.2).AND.(FMACH.LE.1.1)) CALL MCDEVT (FMACH,ARW,CLAW)
      CLPW=CLPW1*CLAW/(PI*ARW/2.)
      CLDW=CLDW1*CLAW/(PI*ARW/2.)
      XCPW=(CPW*CRW + XWING)
      BMW=99.9999E+30
      IF(TANLW.GT.0.0) BMW=BETA/TANLW
      CALL INTSLB (1,FMACH,BETA, BMW,RBW,CRW,TRW,BOW,ARW,CLAW,
     1  BKWB,BKBW,SKWB,SKBW)
      FW=(BKWB + BKBW)*CLAW*AWAR
      ARMWH=(HINGW-XCPW)/DREF
      CHAW=BKWB*CLAW*(AWAR/2.)*ARMWH
      CHDW=SKWB*CLAW*(AWAR/2.)*ARMWH
      CNDW=(SKWB+SKBW)*CLAW*AWAR
      ARMW=(XCG-XCPW)/DREF
      CNDWCG=CNDW*ARMW
      CMQW=-2.*(FW *ARMW**2)
      CMACGW=FW *ARMW
561      CONTINUE
      ............................    TAIL FORCE COEFF.
      FTI=0.
      XCPT=0.
      CMQT=0.
      CMACGT=0.
      CLPT=0.
      IF(BOT.EQ.0.0) GO TO 651
      CALL BRIT (FMACH,ART,TRT,SWHAT,CLAT,CPCB)
      CPT=CPCB*CBART + XMT
      IF((MCDVT.EQ.2).AND.(FMACH.LE.1.1)) CALL MCDEVT (FMACH,ART,CLAT)
      CLPT=CLPT1*CLAT/(PI*ART/2.)
      CLDT=CLDT1*CLAT/(PI*ART/2.)
      XCPT=(CPT*CRT + XTAIL)
      BMT=99.9999E+30
      IF(TANLT.GT.0.0) BMT=BETA/TANLT
      CALL INTSLB (1,FMACH,BETA, BMT,RBT,CRT,TRT,BOT,ART,CLAT,
     1  BKTB,BKBT,SKTB,SKBT)
```

81

```
BTAIL=XL-XTAIL-CRT
XXLB=XLBOD*DREF
DDB=DBOD*DREF
CALL ARAT(FMACH,CRT,BTAIL,XXLB,DDB,DCY,A1A)
BKBT=BKBT*A1A
SKBT=SKBT*A1A
FT=(BKTB + BKBT)*CLAT*ATAR
CNDT=(SKTB+SKBT)*CLAT*ATAR
CMDTCG=CNDT*(XCG-XCP1)/DREF
..............................          VORTEX CALCULATION
CLIA=0.0
X1=0.0
FWSW=0.0
ARMT=(XCG-XCPI)/DREF
ARMTH=(HINGT-XCPT)/DREF
IF(BOW.EQ.0.0) GO TO 655
XHW=+XCPW-XWING
XBART=+XCPT-XTAIL
ALP=.5
CALL FACTOR (BOW,RBW,CRW,XHW,XWING,0.,BOT,RBT,TRT,XTAIL,XBART,
1   ALP,X1,FWSW)
FWMRW = FWSW*BOW
CLIA=(CLAW*CLAI*BKWB*X1*BOT/(2.*PI*ART*FWMRW))*AWAR
CLIDW=(CLAW*CLAT*SKWB*X1*BOT/(2.*PI*ART*FWMRW))*AWAR
CMIDWC=CLIDW*ARMT
655    CONTINUE
FTI=FT + CLIA
FTRAT=FTI/(FT+SMALL)
CHAT=(BKTB*CLAT*ATAR + CLIA)*.5*ARMTH
CHDT=(SKTB*CLAT*ATAR + CLIA)*.5*ARMTH
CMQT=-2.*(FTI*ARMT**2)
CMACGT=FTI*ARMT
651    CONTINUE
IF((BOT.EQ.0.).OR.(BOW.EQ.0.)) GO TO 652
CNDW=CNDW+CLIDW
CMDWCG=CMDWCG+CMIDWC
652    CONTINUE


IF (NOUT.NE.1) WRITE (6,199)
WRITE (6,198)
WRITE (6,198)
WRITE (6,4040)
WRITE (6,410) FMACH,XCG,WEIGHT,ALT,RE
WRITE (6,4041)
WRITE (6,400)
WRITE (6,401) CNAB,XCPB,CMACGB,CMQB
IF (BOW.EQ.0) GO TO 653
WRITE (6,402) BKWB,BKBW,CLAW,CPW,FW,XCPW,CMACGW,CMQW,CLPW,
+CLDW,CHAW,CHDW,CNDW,CMDWCG
653    IF (BOT.EQ.0) GO TO 654
WRITE (6,403) BKTB,BKBT,CLAT,CPT,FTI,XCPT,CMACGT,CMQT,CLPT,
+CLDT,CHAT,CHDT,CNDT,CMDTCG
654    CONTINUE


COMPLETE CONFIGURATION

CNA=CNAB + FW + FTI
CMA=CMAB + FW*XCPW/DREF + FTI*XCPT/DREF
XCP=CMA*DREF/(CNA + SMALL)
CMQ=CMQB + CMQW + CMQT
CMACG=CMACGB + CMACGW + CMACGT          82
```

```
CLP=CLPW + CLPT
SIGMA=SQRT(ABS(CMACG)*Q*AREFFT*DREFFT/(YIY+SMALL))/(2.*PI)

WRITE (6,404) CNA,XCP,CMACG,CMO,CLP
WRITE (6,4444) SIGMA


.......................................

   END ZERO ALPHA LOOP

.......................................
DO 92 L1=1,NDELT
DELT=TDELT(L1)
DO 92 L2=1,NDELW
DELW=TDELW(L2)

..................           TRIM CONDITIONS

IF (NOUT.EQ.2) GO TO 94
ALP=-(CMDWCG*DELW + CMDTCG*DELT)/CMACG
NTRIM=100
DO 95 ITR=1,NTRIM
CALL HIGHALP (FMACH,XCG,ALP,DELW,DELT,CN,XCP,CMCG,CHW,CHT,
+ FTRAT,DREF)
DALPS=0.5
IF (ALP.LT.0) DALPS=-0.5
ALPS=ALP - DALPS
CALL HIGHALP (FMACH,XCG,ALPS,DELW,DELT,X1,X2,CMCG1,X3,X4,X5,DREF)
CMCGS=(CMCG-CMCG1)/DALPS
DALP=CMCG/(CMCGS + SMALL)
IF (ABS(DALP).LE.0.1) GO TO 96
ALP=ALP - DALP
95     CONTINUE
WRITE (6,452) NTRIM,DELW,DELT
GO TO 94
96     ALPMAX=40.
IF (ABS(ALP).LT.ALPMAX) GO TO 97
WRITE (6,455) ALPMAX,DELW,DELT
GO TO 94
97     GLOAD=(CN*COS(ALP/RAD))*Q*AREFFT/WEIGHT
HMW=CHW*Q*AREFFT*DREFFT
HMT=CHT*Q*AREFFT*DREFFT

WRITE (6,198)
WRITE (6,4042)
WRITE (6,454)
WRITE (6,450)
WRITE (6,451) ALP,DELW,DELT,CN,XCP,CMCG,HMW,HMT,FTRAT,GLOAD

..................           ALPHA CONDITIONS
94     IF (NOUT.EQ.1) GO TO 92
ACON(1)='      '
ACON(2)='      '
ACON(3)='      '
H(1)=NALP
H(2)=NRUN
H(3)=1
H(4)=PHIT
H(5)=FMACH
H(6)=RE/1.E6
WRITE (6,4043)
WRITE (6,456) NRUN
WRITE (6,453)
```

83

```fortran
      DO 93 L3=1,NALP
      ALP=IALP(L3)
      CALL HIGHALP (FMACH,XCG,ALP,DELW,DELI,CN,XCP,CMCG,CHW,CHT,
     + FIRAT,DREF)
      WRITE (6,451) ALP,CN,XCP,CMCG,CHW,CHT,FIRAT,
     + CNBI,XCPBY,CNW,XCPWN,CNI,XCPIL,CLTV
      Y(L3,1)=ALP
      Y(L3,2)=CN
      Y(L3,3)=CMCG
93    CONTINUE
      IF (NDBASE.EQ.2) CALL DATA (ACON,H,Y)
      NRUN = NRUN + 1
92    CONTINUE
91    CONTINUE
90    CONTINUE
      STOP
      END
      SUBROUTINE HIGHALP (FMACH,XCG,ALPHA,DELW,DELT,CN,XCP,CMCG,
     + CHW,CHT,FTRAT,DREF)
      HIGH ANGLE OF ATTACK AERO
      ALL GEOMETRIC VARIABLES MUST HAVE SAME SYSTEM OF UNITS.
      I.E.,  IN., FT., CAL., ETC.

      COMMON /BODY/ XL,XN,RE,D,DCY,ACY,AREF,NOSE,CNAB,XCPB
      COMMON /WING/ BOW,RBW,CRW,XWING,XCENW,PHIW,HINGW,AWAR,ARW
      COMMON /WING2/ CLAW,XCW,BKWB,BKBW,SKWB,SKBW
      COMMON /TAIL/ BOT,RBT,TRT,XTAIL,XCENT,PHIT,HINGT,ATAR,ART
      COMMON /TAIL2/ CLAT,XCT,BKTB,BKBT,SKTB,SKBT
      COMMON /PARTS/ CNBY,XCPBY,CNW,XCPW,CNI,XCPT,CLI

C.............................    BODY FORCES

      SMALL=1.0E-30
      RAD=57.29578

      ALP=ABS(ALPHA)
      XL2=XL/DCY
      XN2=XN/DCY
      XCG2=XCG/DCY
      CALL CROSFLO (FMACH,ALP,RE,D,XL2,XN2,NOSE,XCG2,CNV,CMV,X3)
      CALL CROSFL1 (FMACH,ALP,1,1,XN2,XL2,XCG2,X1,X2,XCPV2)
      XCPV=XCPV2*DCY
      CNV=CNV*ACY/AREF

      CNABD=CNAB/RAD
      CNBY=CNABD*ALP + CNV
      XCPBY=XCPB
      IF(ALPHA.EQ.0.) GO TO 44
      XCPBY=(XCPB*CNABD*ALP+XCPV*CNV)/(CNBY+SMALL)
      IF(ALPHA.LT.0.) CNBY=-CNBY
C..............................    WING FORCES
44    IF(BOW.NE.0.0) GO TO 750
      CLW=0.0
      XCPW=0.0
      CHW=0.0
      GO TO 751
750   CONTINUE
      D1=ALPHA + DELW
      CLAWD=CLAW/RAD
      CLWA=CLAWD*ALPHA
      CLWD=CLAWD*DELW
      XCPW=XCW
      ARMHW=(HINGW-XCPW)/DREF
```
84

```
CL=(( BKWB+ BKBW)*CLWA + ( SKWB+ SKBW)*CLWD)*AWAR
CHW=(BKWB*CLWA + SKWB*CLWD)*ARMHW*AWAR/2.
CHW=CHW*(COS(D1/RAD) + SIN(D1/RAD)**2)
.............................            TAIL FORCES
751    IF(BUT.NE.0.0) GO TO 650
CLTI=0.0
XCPT=0.0
CHT=0.0
GO TO 651
650    CONTINUE
D2=ALPHA + DELT
CLATD=CLAT/RAD
CLTA=CLATD*ALPHA
CLTD=CLATD*DELT
XCPT=XCT
CLT=(( BKTB+ BKBT)*CLTA + ( SKTB+ SKBT)*CLTD)*ATAR
XHW=HINGW-XWING
XBART=+XCPT-XTAIL
CLI=0.
IF(BOW.EQ.0.) GO TO 68
CALL VORTEX (BOW,RBW,CRW,XHW,XWING,DELW,PHIW,AWAR,BOT,RBT,TRT,
C  XTAIL,XBART,PHIT,ART,ALPHA,CLAW,CLAT,BKWB,SKWB,CLI,F*SW)
68     CONTINUE
ARMHT=(HINGT-XCPT)/DREF
CHT=(BKTB*CLTA + SKTB*CLTD + CLI)*ARMHT*ATAR/2.
CHT=CHT*(COS(D2/RAD) + SIN(D2/RAD)**2)
CLTI=CLT+CLI
FTRAT=CLTI/(CLT + SMALL)
651    CONTINUE
.............................            COMPLETE CONFIGURATION
CNW=CLW
CNT=CLT
CNTI=CLTI
CN    =CNBY+CNW+CNTI
CM    =+CNBY*XCPBY+CNW*XCPW+CNTI*XCPT
XCP=CM/(CN + SMALL)
CMCG=(+CNBY*(XCG-XCPBY)+CNW*(XCG-XCPW)+CNTI*(XCG-XCPT))/DREF
RETURN
END
SUBROUTINE DATA1
INITIALIZE DATA BASE FILE INPUT.
N2        = NO. OF COEFFICIENTS.
N3        = NO. OF PARAMETERS.
CHARACTER*18 OFILE
COMMON /PACK/ IC(2),IP,N2,N3
200    FORMAT (1H0,'ENTER: IC(1) - 8 HEX. CHAR., I.E., A8CDEF12')
201    FORMAT (1H0,'ENTER: IC(2) - 8 HEX. CHAR., I.E., C0280000')
202    FORMAT (1H0,'ENTER: IP  - 8 HEX. CHAR., I.E.,  AF2E1000')
210    FORMAT (Z8)
300    FORMAT(1H0,'ENTER DATA BASE FILE NAME - I.E., DATA:ZCOPHED.DAT')
400    FORMAT(A18)
401    FORMAT (1H0,'PROBLEM WITH FILE=',A18,3X,'ISTAT=',I4)


13     WRITE(1,300)
READ(1,400)OFILE
OPEN(10,FILE=OFILE,FORM='BINARY',COUNTBY='RECORD'
*,RECL=32,BLOCKSIZE=32,IOSTAT=ISTAT,ACCESS='DIRECT'
*,STATUS='NEW')

IF (ISTAT .EQ. 0)GO TO 12
WRITE (1,401) OFILE,ISTAT
PAUSE 'CORRECT PROBLEM AND CONTINUE'
```

```
        GO TO 13

12      CONTINUE
N2=3
N3=6

WRITE (1,200)
READ (5,210) IC(1)
WRITE (1,201)
READ (5,210) IC(2)
WRITE (1,202)
READ (5,210) IP

RETURN
END
SUBROUTINE DATA (ACON,H,Y)
DIMENSION Y(25,3), ACON(3), H(32), C(2,64)
COMMON /PACK/ IC(2),IP,N2,N3
H        = VALUE OF HEADING PARAMETERS.
Y        = COEFF. ARRAY AT EACH DATA POINT.
ACON     = CONFIGURATION NAME - 3 WORDS - 12 CHARACTERS.
C        = MAX AND MIN VALUES. (LOAD ZERO)
        CORFILE.FIN  PROGRAM DETERMINES MAX'S AND MIN'S.

DO 10 I=1,2
DO 10 J=1,64
10      C(I,J)=0.
WRITE (10) N2,N3,IC,IP,ACON
WRITE (10) (H(I), I=1,N3)
WRITE (10) (C(1,I),I=1,N2)
WRITE (10) (C(2,I),I=1,N2)
NPTS=H(1)
DO 50 I=1,NPTS
50      WRITE (10) (Y(I,J),J=1,N2)
RETURN
END
SUBROUTINE BODY(NOSE,XLN,XLA,FMACH,CNA,XCP)
INPUTS
NOSE = 1     OGIVE NOSE
NOSE = 2     CONICAL NOSE
XLN = NOSE LENGTH (CAL)
XLA = AFTERBODY LENGTH (CAL)
OUTPUT
CNA = NORMAL FORCE COEFF. (1/RAD)
XCP = CENTER OF PRESSURE (CAL FROM NOSE)
TABLE 1 = BODY DATA FOR TANGENT OGIVE NOSE WITH VARIOUS NOSE LENGTHS
TABLE 2 = BODY DATA FOR TANGENT OGIVE NOSE WITH VARIOUS AFTERBODY LENGTHS
TABLE 3 = BODY DATA FOR CONICAL NOSES OF VARIOUS ANGLES
TABLE 4 = BODY DATA FOR CONICAL NOSE WITH VARIOUS AFTERBODY LENGTHS
DIMENSION TMACH(15),TCNA1(15,3),TXCP1(15,3),TXLN(3),TCNA2(15,3)
8,TXCP2(15,3),TXLA(3),TANG(4),TALA(5),TCNA3(15,4),TXCP3(15,4),
8TCNA4(15,5),TXCP4(15,5)
DATA (TMACH(I),I=1,15)/.8,.9,1.,1.05,1.1,1.2,1.4,1.6,1.8,2.,2.5,
83.,3.5,4.,4.5/
DATA (TXLN(I),I=1,3)/3.,4.,5./
DATA(TXLA(I),I=1,3)/4.,6.,8./
DATA(TANG(I),I=1,4)/6.,7.125,8.,10./
DATA(TALA(I),I=1,5)/4.,6.,8.,9.5,11./
DATA ((TCNA1(I,J),I=1,15),J=1,3)/.042,.043,.0465,.048,.0465,.0455,
8.0435,.0432,.044,.045,.05,.054,.055,.0575,.0575,.043,.044,.0465,
8.048,.0465,.044,.042,.0412,.0415,.0425,.047,.0518,.055,.055,.0545,
8.044,.045,.046,.048,.0465,.043,.042,.0405,.0408,.041,.0445,.05,.05
82,.053,.054/
```

86

```
DATA((TXCP1(I,J),I=1,15),J=1,3)/.65,.55,.25,.17,.25,.65,.97,1.08,
$1.08,1.05,.88,.7,.5,.3,.08,1.17,1.05,.55,.45,.65,1.,1.4,1.57,1.6,
$1.58,1.46,1.3,1.1,.9, .65 ,1.6,1.35,.9,.77,.98,1.51,1.93,2.1,2.12,
$2.1,2.,.1.9,1.69,1.47,1.2/
DATA((TCNA2(I,J),I=1,15),J=1,3)/0.0415,0.044,0.0465,0.048,0.0465,
$0.0445,0.042,0.0418,0.042,0.0425,0.0470,.0515,.054,.055,.056,.043,
$0.045,0.048,0.0505,0.0495,0.047,0.0448,0.044,0.0445,0.045,0.049,
$0.053,0.0545,0.056,0.0575,0.045,0.047,0.051,0.052,0.0515,0.0495,
$0.047,0.0462,0.046,0.0465,0.0495,0.053,0.0552,0.057,0.058/
DATA((TXCP2(I,J),I=1,15),J=1,3)/1.62,1.4,1.05,0.92,1.15,1.48,1.95,
$2.1,2.1,2.08,1.97,1.81,1.57,1.3,1.2,1.15,0.90,0.40,0.25,0.045,1.05
$,1.58,1.84,1.90,1.90,1.78,1.65,1.4,1.13,0.98,0.72,0.41,-0.10,-0.25
$,0.0,0.75,1.4,1.65,1.70,1.70,1.55,1.4,1.2,1.0,0.82/
DATA((TCNA3(I,J),I=1,15),J=1,4)/0.0405,0.042,0.046,0.0475,0.0455,
$0.044,0.042,0.041,0.041,0.042,0.044,0.048,0.052,0.0535,0.053,0.040
$5,.042,0.046,0.0475,0.0455,0.044,0.042,0.042,0.042,0.043,0.046,
$0.05,0.053,0.055,0.056,0.0405,0.042,0.046,0.0475,0.0455,0.044,0.04
$4,0.042,0.043,0.044,0.047,0.051,0.0545,0.057,0.058,0.0405,0.042,
$0.046,0.0475,0.0455,0.044,0.0438,0.0435,0.044,0.045,0.049,0.053,
$0.057,0.059,0.060/
DATA((TXCP3(I,J),I=1,15),J=1,4)/0.75,0.552,0.20,0.05,0.325,0.65,
$0.94,1.05,1.1,1.09,0.90,0.65,0.42,0.24,0.20,0.55,0.40,0.05,-0.10,
$0.15,0.47,0.70,0.85,0.85,0.83,0.60,0.37,0.15,-0.05,-0.11,0.37/0.20
$,-0.10,-0.20,0.0,0.30,0.57,0.70,0.70,0.65,0.45,0.22,-0.01,-0.20,
$-0.27,0.20,0.05,-0.30,-0.38,-0.25,0.05,0.30,0.45,0.47,0.43,0.242,
$-0.05,-0.30,-0.48,-0.50/
DATA((TCNA4(I,J),I=1,15),J=1,5)/0.039,0.041,0.0445,0.045,0.0435,
$0.043,0.041,0.040,0.0415,0.042,0.046,0.049,0.0515,0.053,0.054,
$0.0405,0.042,0.046,0.0475,0.0455,0.044,0.042,0.042,0.042,0.043,
$0.046,0.050,0.053,0.055,0.056,0.0435,0.045,0.0485,0.052,0.0515,
$0.049,.046,.045,.045,.046,.047,.051,.054,.055,.057,.044,.046,
$0.050,0.051,0.050,0.047,0.044,0.0435,0.044,0.045,0.047,0.050,0.054
$,0.056,0.057,0.045,0.047,0.051,0.053,0.051,0.048,0.043,0.042,0.042
$,0.0432,0.047,0.050,0.054,0.057,0.058/
DATA((TXCP4(I,J),I=1,15),J=1,5)/0.90,0.75,0.55,0.38,0.50,0.72,0.90
$,0.94,0.90,0.80,0.60,0.41,0.25,0.15,0.15,0.55,0.40,0.05,-0.10,0.15
$,.47,0.70,0.85,0.85,0.83,0.60,0.37,0.15,-0.05,-0.11,-0.11,-0.45,
$-0.75,-0.90,-0.65,-0.25,0.25,0.45,0.53,0.55,0.50,0.30,0.10,-0.15,
$-0.35,-0.30,-0.60,-1.20,-1.30,-1.05,-0.60,0.0,0.30,0.42,0.40,0.40,
$0.20,0.0,-0.24,-0.45,-0.55,-0.80,-1.45,-1.65,-1.50,-1.0,-0.30,0.13
$,0.28,0.39,0.30,0.10,-0.15,-0.35,-0.60/
RAD = 57.29578
IF (NOSE.EQ.2) GO TO 10
-------------------------------------                OGIVE-CYLINDER
CALL TABLE2 (2,CNA1,TCNA1,FMACH,TMACH,15,3,XLN,TXLN,3,2)
CALL TABLE2 (2,CNA2,TCNA2,FMACH,TMACH,15,3,XLA,TXLA,3,2)
CALL TABLE2 (2,CNA3,TCNA2,FMACH,TMACH,15,3,6.0,TXLA,3,2)
CNA = (CNA1+CNA2-CNA3)*RAD
CALL TABLE2 (2,XCP1,TXCP1,FMACH,TMACH,15,3,XLN,TXLN,3,2)
CALL TABLE2 (2,XCP2,TXCP2,FMACH,TMACH,15,3,XLA,TXLA,3,2)
CALL TABLE2 (2,XCP3,TXCP2,FMACH,TMACH,15,3,6.0,TXLA,3,2)
XCP=XLN-(XCP1+XCP2-XCP3)
GO TO 11
-------------------------------------                CONE-CYLINDER
10    ANG=ATAN (.5/XLN)
CALL TABLE2 (2,CNA4,TCNA3,FMACH,TMACH,15,3,ANG,TANG,4,2)
CALL TABLE2 (2,CNA5,TCNA4,FMACH,TMACH,15,3,XLA,TALA,5,2)
CALL TABLE2 (2,CNA6,TCNA4,FMACH,TMACH,15,3,6.0,TALA,5,2)
CNA=(CNA4+CNA5-CNA6)*RAD
CALL TABLE2 (2,XCP4,TXCP3,FMACH,TMACH,15,3,ANG,TANG,4,2)
CALL TABLE2 (2,XCP5,TXCP4,FMACH,TMACH,15,3,XLA,TALA,5,2)
CALL TABLE2 (2,XCP6,TXCP4,FMACH,TMACH,15,3,6.0,TALA,5,2)
XCP=XLN-(XCP4+XCP5-XCP6)
```

```
11      RETURN
END
SUBROUTINE BOATL (FMACH,DBOD,XLBOD,CNA,XCPOD)
COMPUTES (CNA) AND (XCP) FOR CONICAL BOATTAILS
REF. MICOM REPORT NO. RD-TM-68-5
  BY. W. D. WASHINGTON
INPUTS
FMACH = FREE STREAM MACH NUMBER
DBOD  = DIAMETER RATIO (BOATTAIL/CYLINDER)
XLBOD = BOATTAIL LENGTH/CYLINDER DIAMETER
OUTPUT
CNA    = BOATTAIL NORMAL FORCE COEFF., BASED ON CYLINDER AREA-1/RAD
XCPOD = BOATTAIL CENTER OF PRESSURE, CALIBERS FROM LEADING EDGE
DIMENSION TFMACH(11),TXCPLB(11),TBETLB(18),TCNPR(18)
DATA (TXCPLB(I), I=1,11) /.41,.41,.41,.415,.425,.45,.48,.52,.58,
+ .635,.7/
DATA (TFMACH(I), I=1,11) /.0,.5,1.,1.5,2.,2.5,3.,3.5,4.,4.5,5./
DATA (TBETLB(I), I=1,18) /-2.,-1.5,-1.,-.75,-.5,-.25,0.,.25,.5,
+ .75,1.,1.25,1.5,2.,3.,4.,5.,6./
DATA (TCNPR(I), I=1,18) /2.01,2.01,2.03,2.12,2.52,2.92,3.09,2.87,
+ 2.35,1.66,1.15,1.,.93,.83,.69,.57,.5,.43/
BETLB=SQRT(ABS(FMACH**2-1.))/XLBOD
IF(FMACH.LT.1.) BETLB=-BETLB
IF(BETLB.LE.6.) GO TO 10
WRITE (6,500) BETLB
500  FORMAT (1H0,'BETLB='F10.2,5X,'OUTSIDE TABLE 5.0, LAST POINT USED')
BETLB=6.0
10   XMACH=FMACH
IF(FMACH.LE.5.) GO TO 11
WRITE (6,501) FMACH
501  FORMAT (1H0,'FMACH,'F10.2,5X,'OUTSIDE TABLE 5.0, LAST POINT USED')
XMACH=5.0
11   CALL INTERP (2,1,CNPR,TCNPR,BETLB,TBETLB,18,2,MINX,MAXX)
CALL INTERP (2,1,XCPLB,TXCPLB,XMACH,TFMACH,11,2,MINX,MAXX)
CNA=-CNPR*(1.-DBOD**2)
XCPOD=XCPLB*XLBOD
RETURN
END
SUBROUTINE CROSFLO(FMACH,ALP,RE,D,LODT,LODN,NOSE,XCG,CNV,CMV,XCPV)
CALCULATE VISCOUS COMPONENTS OF NORMAL FORCE AND PITCHING MOMENT
USING ALLEN'S METHOD WITH MODIFIED CDC CURVE.
INPUTS:
FMACH    = FREE STREAM MACH NUMBER.
ALP      = ANGLE OF ATTACK - DEG.
RE       = FREE STREAM REYNOLDS NO. - 1/FT.
D        = CYLINDER DIAMETER - FT.
LODT     = TOTAL BODY LENGTH - CALIBERS.
LODN     = NOSE LENGTH - CALIBERS.
NOSE     = 1  OGIVE
         = 2  CONE
XCG      = CENTER OF GRAVITY - CALIBERS FROM NOSE.
OUTPUTS:
CNV      = VISCOUS COMPONENT OF NORMAL FORCE
CMV      = VISCOUS COMPONENT OF PITCHING MOMENT, ABOUT XCG.
XCPV     = VISCOUS COMPONENT CENTER OF PRESSURE - CAL. FROM NOSE.
NOTES:
     1 CALIBER IS 1 CYLINDER DIAMETER (D).
     CNV AND CMV ARE BASED ON CYLINDER CROSS SECTIONAL AREA
     AND DIAMETER.

DIMENSION TLOD(7),TETAO(7),TMN(22),TCDC(22),TMN2(6),TCDC2(6)
REAL MN,LODN,LODA,LODT
DATA TLOD /0.,5.,10.,15.,20.,30.,40./
```
88

```
DATA IETAO /.53,.63,.69,.74,.76,.80,.82/
DATA IMN /.0,.1,.2,.3,.4,.5,.6,.7,.8,.85,.9,.94,
+  1.0,1.1,1.2,1.4,1.6,1.8,2.0,2.4,2.8,3.0/
DATA TCDC /1.2,1.18,1.18,1.2,1.23,1.28,1.37,
+  1.52,1.45,1.42,1.64,2.08,2.0,
+  1.67,1.80,1.82,1.85,1.85,1.85,
+  1.8,1.69,1.50,1.48,1.43,1.40,1.36,1.34,1.34/
DATA IMN2 /.0,.1,.2,.3,.4,.5/
DATA TCDC2 /.30,.37,.48,.72,.96,1.28/

DEG=57.29578
PI=3.14159
SMALL=1.E-30


IF (NOSE.EQ.1) GO TO 16
              CONE PLANFORM AREA AND CENTROID
AP1=(LODN/2.)*4./PI
XB1=.6667*LODN
GO TO 15
              OGIVE PLANFORM AREA AND CENTROID
16    BROD=LODN**2 + .25
XB1=.55*LODN
AP1=-2.*LODN*(BROD-.5) + LODN*SQRT(BROD**2-LODN**2)
+    +BROD**2*ASIN(LODN/BROD)
AP1=AP1*4./PI
            ADD CYLINDERICAL AFTERBODY
15    LODA=LODT - LODN
AP2=LODA*4./PI
XB2=.5*LODA
APOAR=AP1 + AP2
XCPV=(XB1*AP1 + (LODN + XB2)*AP2)/APOAR

MN=FMACH*SIN(ALP/DEG)
REN=RE*D*SIN(ALP/DEG)
CALL INTERP (2,1,ETAO,IETAO,LODT,TLOD,7,2,MIN,MAX)
RECRIT=1.E05

ETA=ETAO

IF (REN.LE.RECRIT) GO TO 10
IF (MN.GE.0.5) GO TO 10
CALL INTERP (2,1,CDC,TCDC2,MN,TMN2,6,2,MIN,MAX)
GO TO 11
10    CALL INTERP (2,1,CDC,TCDC,MN,TMN,22,2,MIN,MAX)
11    CNV=CDC*ETA*APOAR*SIN(ALP/DEG)**2
CMV=CNV*(XCG-XCPV)
RETURN
END
SUBROUTINE CROSFL1 (FMACH,ALP,LT,NOSE,XNOSE,XTOT,XCG,CNV,CMV,XCPV)
CALCULATE VISCOUS COMPONENTS OF NORMAL FORCE AND PITCHING MOMENT
USING CROSS FLOW DRAG METHOD OF PERKINS AND JORGENSEN.
INPUTS:
FMACH    = FREE STREAM MACH NO.
ALP      = ANGLE OF ATTACK - DEG.
LT       = 1  LAMINAR BOUNDARY LAYER.
     = 2  TURBULENT BOUNDARY LAYER.
NOSE     = 1  OGIVE NOSE.
     = 2  CONE NOSE.
XNOSE    = NOSE LENGTH - CALIBERS
XTOT     = TOTAL BODY LENGTH - CALIBERS
XCG      = CENTER OF GRAVITY - CALIBERS FROM NOSE
OUTPUTS:
CNV      = VISCOUS COMPONENT OF NORMAL FORCE
```
89

```
CMV       = VISCOUS COMPONENT OF PITCHING MOMENT
NOTES:
     1 CALIBER IS 1 CYLINDER DIAMETER (D).
     CNV AND CMV ARE BASED ON CYLINDER CROSS SECTIONAL AREA
     AND DIAMETER.

DIMENSION IXOLM(21),TCDRL(21),TCDRT(21),TMC(21),TCDCP(21)
DIMENSION IBOXN(11),TLMO(11),TLMC(11)
REAL LM,LMOXN,MC

DATA IXOLM /.0,.1,.2,.3,.4,.5,.6,.7,.8,.9,1.0,1.1,1.2,
+  1.3,1.4,1.5,1.6,1.7,1.8,1.9,2.0/
DATA TCDRL /.0,.025,.085,.185,.35,.63,.93,1.20,1.38,1.49,
+  1.48,1.40,1.30,1.21,1.14,1.08,1.04,1.00,.97,.94,.92/
DATA TCDRT /.0,.01,.05,.10,.25,.50,.80,1.0,1.1,1.1,
+  1.03,.96,.90,.85,.82,.80,.80,.80,.80,.80,.80/
DATA TMC /.0,.1,.2,.3,.4,.5,.6,.7,.8,.9,1.0,1.1,1.2,
+  1.3,1.4,1.5,1.6,1.7,1.8,1.9,2.0/
DATA TCDCP /1.2,1.18,1.16,1.2,1.25,1.36,1.53,1.73,1.82,
+  1.82,1.79,1.74,1.67,1.60,1.53,1.46,1.40,1.37,1.33,1.30,1.28/
DATA TBOXN /.0,.1,.2,.3,.4,.5,.6,.7,.8,.9,1.0/
DATA TLMO /1.0,1.09,1.22,1.39,1.57,1.76,1.98,2.20,2.42,2.65,2.88/
DATA TLMC /1.0,1.21,1.42,1.63,1.84,2.05,2.27,2.47,2.67,2.89,3.09/


SMALL=1.E-30
DEG=57.29578
PI=3.14159
LMOXN=1.0
IF (FMACH.LE.1.0) GO TO 11
BOXN=SQRT(FMACH**2-1.)/XNOSE
IF (NOSE.EQ.2) GO TO 10
CALL INTERP (2,1,LMOXN,TLMO,BOXN,TBOXN,11,2,MIN,MAX)
GO TO 11
10     CALL INTERP (2,1,LMOXN,TLMC,BOXN,TBOXN,11,2,MIN,MAX)
11     LM=LMOXN*XNOSE
.............................. CALCULATE CDCP
MC=FMACH*SIN(ALP/DEG)
CALL INTERP (2,1,CDCP,TCDCP,MC,TMC,20,2,MIN,MAX)

SUMN=0.
SUMM=0.
FN1=0.
FM1=0.
X1=0.
I=2
56     X2=X1 + .1*LM
IF (X2.LE.XTOT) GO TO 54
X2=XTOT
XOLM=X2/LM
IF (LT.EQ.2) GO TO 55
CALL INTERP (2,1,CDR2,TCDRL,XOLM,TXOLM,21,2,MIN,MAX)
GO TO 51
55     CALL INTERP (2,1,CDR2,TCDRT,XOLM,TXOLM,21,2,MIN,MAX)
GO TO 51
54     IF (LT.EQ.2) GO TO 50
CDR2=TCDRL(I)
GO TO 51
50     CDR2=TCDRT(I)

51     N2=.5
IF(X2.GE.XNOSE) GO TO 53
IF (NOSE.EQ.2) GO TO 52
BIGR=.25 + XNOSE**2
```
90

```
      R2=SQRT(BIGR**2-(XNOSE-X2)**2)-(BIGR-.5)
      GO TO 53
52    R2=X2*(1./XNOSE)/2.

53    FN2=CDR2*R2
      FM2=FN2*(XCG-X2)
      DN=(FN2 + FN1)*(X2-X1)/2.
      DM=(FM2 + FM1)*(X2-X1)/2.
      SUMN=SUMN + DN
      SUMM=SUMM + DM

      X1=X2
      FN1=FN2
      FM1=FM2
      I=I + 1
      IF (I.GT.21) I=21
      IF (X2.LT.XTOT) GO TO 56

      CONST=(8./PI)*CDCP*SIN(ALP/DEG)**2
      CNV=CONST*SUMN
      CMV=CONST*SUMM
      XCPV=XCG - CMV/(CNV + SMALL)
      RETURN
      END
      SUBROUTINE ARAT(XM,CCR,XX1,XXLB,DDB,D,A1A)
      THIS SUBROUTINE CALCULATES THE SHADED AREA RATIO
      FOR MODIFING CARRYOVER WHEN FINS ARE CLOSE TO BASE OF BODY
      FOR CYLINDER OR BOATTAIL
      XM     = MACH NUMBER
      CCR    = FIN ROOT CHORD
      XX1    = DISTANCE FROM BASE OF MISSILE TO FIN TRAILING EDGE
      XXLB   = LENGTH OF BOATTAIL
      DDB    = DIAMETER OF BASE
      D      = DIAMETER OF CYLINDER
      A1A    = SHADED AREA RATIO
      PROGRAM MODIFIED (9 DEC,71) TO INCLUDE FINS EXTENDED AFT BASE, IAS
      A1A=1.0
      IF(XM.LE.1.0) GO TO 7
      CR=CCR/D
      X1=XX1/D
      XLB=XXLB/D
      DB=DDB/D
      A=CR

      IF(X1.LT. 0.0) CR=CR+X1
      IF(X1.LT. 0.0) X1=0.0

      XLC=CR + X1 - XLB
      BETA=SQRT(XM*XM - 1.0)
      TANMU=1.0/BETA
      TANTH=0.0
      IF(XLB.NE.0.0) TANTH=.5*(1.0-DB)/XLB
      TANTH=(TANTH + TANMU)/(1.0-TANTH*TANMU)
      C1=SQRT(1.0 + XLC*XLC)
      C2=SQRT(1.0 + ((XLC + XLB)/(.5*(1.0 + DB)))**2)
      C3=SQRT(1.0 + (TANTH + X1*(1.0 + TANTH**2)/DB)**2)
      IF((XM.GE.1.0).AND.(XM.LE.C1)) I=1
      IF((XM.GT.C1).AND.(XM.LE.C2)) I=2
      IF((XM.GT.C2).AND.(XM.LE.1.0E+25)) I=3
      IF((XM.GT.C3).AND.(XM.LE.1.0E+25)) J=1
      IF((XM.GE.1.0).AND.(XM.LE.C3)) J=2
      GO TO (1,2,3), I
1     B=0.
```

91

```
       H=BETA
       C=0.
       H1=0.
       GO TO (4,5), J
2          B=1.0-XLC/BETA
       H=XLC
       C=0.
       H1=B/(TANTH + TANMU)
       GO TO (4,5), J
3          B=1.0-XLC/BETA
       H=XLC
       C=.5*(1.0+DB)-(XLC+XLB)/BETA
       H1=XLB
       GO TO (4,5), J
4          E=1.0-2.0*(XLB-X1)*TANTH
       F=DB-X1*(TANTM-TANTH)
       H2=X1
       GO TO 6
5          E=1.0-2.0*(XLB-X1)*TANTH
       F=0.
       H2=E/(TANTH+TANTM)
       GO TO 6
6          A1=.5*(2.0*XLC+(1.0+DB)*XLB-(1.0+B)*H-(B+C)*H1-(E+DB)*X1+(E+F)*H2)
       A1A=A1/A
7          RETURN
       END
       SUBROUTINE READX (LU,LRECL,HOL,FLO,LH,LF,EOFF)

       IMPROVED VERSION OF FFREAD
       BY J.M. CHAFIN

       DIMENSION FORM(6),IBUF(132),JBUF(33),HOL(1),FLO(1)
1060       FORMAT (132A1)
1260       FORMAT('(A',I2,')')
1270       FORMAT('(',I2,'XA',I2,')')
1280       FORMAT('(',I2,'A4,A',I2,')')
1290       FORMAT('(',I2,'X',I2,'A4,A',I2,')')
1360       FORMAT('(',I2,'XF',I2,'.1)')
1400       FORMAT('(F',I2,'.1)')
1460       FORMAT('(',I2,'XI',I2,')')
1500       FORMAT('(I',I2,')')
```

PURPOSE

READS ONE CARD IN FREE FIELD FORMAT (UP TO 132 CHARS)
ANY COMMENT CARDS ENCOUNTERED IN THE DATA DECK ARE
SKIPPED AND NOT INTERPRETED

ARGUMENTS   I=INPUT
---------   O=OUTPUT

LU   -- I -- LOGICAL UNIT NUMBER OF INPUT DEVICE
LRECL-- I -- LOGICAL RECORD LENGTH IN CHARACTERS (132 MAX)
HOL   -- O -- WILL CONTAIN HOLLERITHS FOUND ON RECORD (33 MAX)
FLO   -- O -- WILL CONTAIN FLOATS FOUND ON RECORD
LH   -- O -- NUMBER OF HOLLERITHS ON RECORD
LF   -- O -- NUMBER OF FLOATS ON RECORD
EOFF -- O -- 0 RETURNED IF NO END OF FILE ENCOUNTERED.
EOFF -- O -- 1 RETURNED IF END OF FILE ENCOUNTERED.

DEFINITIONS -- LIMITATIONS

```
----------------------------
A *TRACAR* (TRANSPARENT CHARACTER) IS A BLANK, COMMA OR = SIGN
THE FOLLOWING ARE DELIMITERS
- BEGIN OF CARD
- END OF CARD
- A STRING CONSISTING OF ONE OR MORE TRACARS
AN ITEM CONSISTS OF ONE OR MORE NON-TRACARS PRECEDED AND FOLLOWED BY A
DELIMITER.
EACH ITEM WILL BE INTERPRETED AS EITHER INTEGER, FLOAT, OR HOLLERITH:
ANY ITEM STARTING WITH + - . OR DIGIT WILL BE INTERPRETED AS
- INTEGER IF IT CONTAINS NO .
- FLOAT IF IT CONTAINS ONE .
- HOLLERITH IF IT CONTAINS MORE THAN ONE .
ALL OTHER ITEMS WILL BE INTERPRETED AS HOLLERITHS

----------------------------------------------------------------
INITIALIZE COUNTS AND READ CARD
----------------------------------------------------------------
      EOFF=0
1020  LH=0
      LF=0
      LI=0
1021    READ(LU,1060,END=999) (IBUF(I),I=1,LRECL)
      IF(IBUF(1).EQ.'C'.AND.IBUF(2).EQ.' ') GO TO 1021
      ENCODE(JBUF,1060) (IBUF(I),I=1,LRECL)
      I2=0
----------------------------------------------------------------
FIND I1 = FIRST COLUMN OF FIELD
----------------------------------------------------------------
1100  I1=I2
1120  I1=I1+1
      IF (I1.GT.LRECL) RETURN
      IX=IBUF(I1)
      IF (IX.EQ.' '.OR.IX.EQ.','.OR.IX.EQ.'=') GO TO 1120
----------------------------------------------------------------
FIND I2 = LAST COLUMN OF FIELD
----------------------------------------------------------------
      I2=I1
1140  I2=I2+1
      IF (I2.GT.LRECL) GO TO 1160
      IX=IBUF(I2)
      IF (IX.NE.' '.AND.IX.NE.','.AND.IX.NE.'=') GO TO 1140
      I2=I2-1
      GO TO 1180
1160  I2=LRECL
----------------------------------------------------------------
IW = FIELD WIDTH
----------------------------------------------------------------
1180  NX=I1-1
      IW=I2-I1+1
      DO 1190 I=1,6
1190  FORM(I) ='    '
      IX=IBUF(I1)
      IF(IX.EQ.'+'.OR.IX.EQ.'-'.OR.IX.EQ.'.') GO TO 1200
      IF (IX.GE.'0'.AND.IX.LE.'9') GO TO 1200
      GO TO 1240
----------------------------------------------------------------
COUNT THE DOTS
----------------------------------------------------------------
1200  NDOTS=0
      DO 1220 I=I1,I2
      IF (IBUF(I).EQ.'.') NDOTS=NDOTS+1
```

```
1220 CONTINUE
IF(NOUTS-1) 1440,1340,1240
•••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••
HOLLERITH
•••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••
1240    CONTINUE
NF=IW/4
NP=MAX0(1,MOD(IW,4))
IF(NF.EQ.0.AND.NX.EQ.0) ENCODE(FORM,1260) NP
IF(NF.EQ.0.AND.NX.GT.0) ENCODE(FORM,1270) NX,NP
IF(NF.GT.0.AND.NX.EQ.0) ENCODE(FORM,1280) NF,NP
IF(NF.GT.0.AND.NX.GT.0) ENCODE(FORM,1290) NX,NF,NP
IF(MOD(IW,4).GT.0) NF=NF+1
LH1=LH+1
LHN=LH+NF
DECODE(JBUF,FORM) (HOL(I),I=LH1,LHN)
LH=LH+NF
GO TO 1100
•••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••
FLOAT
•••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••
1340    CONTINUE
IF(NX.EQ.0) ENCODE(FORM,1400) IW
IF(NX.GT.0) ENCODE(FORM,1360) NX,IW
LF=LF+1
DECODE (JBUF,FORM)FLO(LF)
GO TO 1100
•••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••
INTEGER
•••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••
1440    CONTINUE
IF(NX.EQ.0) ENCODE(FORM,1500) IW
IF(NX.GT.0) ENCODE(FORM,1460) NX,IW
LF=LF+1
DECODE (JBUF,FORM) INT
FLO(LF)=FLOAT(INT)
GO TO 1100
•••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••
IF END OF FILE ENCOUNTERED, SET EOFF=1
•••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••
999    EOFF=1
RETURN
END
SUBROUTINE ROLL (BO,CR,TR,RBODY,DREF,AREF,CLP,CLD)

SUBROUTINE FOR CALCULATING ROLL DAMPING AND ROLL MOMENT EFFECTIVENESS.
THEORY FROM  NACA REPORT 1088.

ALL GEOMETRIC INPUTS MUST HAVE SAME SYSTEM OF UNITS.
I.E., FT., IN., CALIBERS, ETC.

BO   = FIN EXPOSED SEMI-SPAN
CR   = FIN ROOT CHORD
TR   = FIN TAPER RATIO
RBODY= RADIUS OF BODY AT FIN
DREF= REFERENCE LENGTH
AREF= REFERENCE AREA

OUTPUT

CLP = ROLL DAMPING COEFFICIENT (BASED ON DREF & AREF)
CLD = ROLLING MOMENT EFFECTIVENESS COEFF (BASED ON DREF & AREF)
   (FOUR FINS DEFLECTED)
```

94

```
DREF=REFERENCE DIAMETER
DIMENSION TLAMDA(11),TCLPAR(11),TCLDAR(11)
DATA TLAMDA/.0,.1,.2,.3,.4,.5,.6,.7,.8,.9,1.0/
DATA TCLPAR/.16,.159,.161,.164,.160,.1475,.120,.086,.043,.013,.0/
DATA TCLDAR/.252,.254,.250,.248,.230,.202,.158,.100,.048,.014,.0/
CLP=0.0
CLD=0.0
DBODY=2.*RBODY
IF(BO.EQ.0.0) RETURN
SPAN=2.*BO + DBODY
XLAMDA=DBODY/SPAN
S=CR*(BO+DBODY/2.)*(1.+TR+(1.-TR)*DBODY/(2.*BO))
AR=SPAN**2/S
CALL INTERP (2,1,CLPAR,TCLPAR,XLAMDA,TLAMDA,11,3,MIN,MAX)
CALL INTERP (2,1,CLDAR,TCLDAR,XLAMDA,TLAMDA,11,3,MIN,MAX)
CLP=-CLPAR*AR
CLD=CLDAR*AR
CLP=CLP*(SPAN/DREF)**2*S/AREF
CLD=CLD*(SPAN/DREF)*S/AREF
RETURN
END
SUBROUTINE FINGEOM (CR,TR,BO,AREF,SWTE,CT,AR,SWLE,CBAR,
+   YBAR,XM,CENT,AFAR,TANL,SWHA)

FIN PANEL GEOMETRY.

ALL GEOMETRIC INPUTS MUST HAVE SAME SYSTEM OF INPUTS.
I.E., FT., IN., CALIBERS, ETC.
OUTPUTS WILL HAVE CONSISTANT UNITS WITH INPUTS.

INPUTS:

CR        = ROOT CHORD
TR        = TAPER RATIO
BO        = EXPOSED SEMI-SPAN
AREF      = REFERENCE AREA
SWTE      = TRAILING EDGE SWEEPBACK ANGLE - DEG.

OUTPUTS:

CT        = TIP CHORD
AR        = ASPECT RATIO ( 1 FIN PANEL ).
    ( SAME FOR 2 FINS JOINED, WITHOUT BODY).
SWLE      = LEADING EDGE SWEEPBACK ANGLE - DEG.
CBAR      = MEAN AERODYNAMIC CHORD / ROOT CHORD.
YBAR      = SPANWISE LOCATION OF M.A.C. / EXPOSED SEMI-SPAN.
XM        = DISTANCE FROM L.E. CR TO L.E. MAC.
CENT      = DISTANCE FROM L.E. CR TO CENTROID.
AFAR      = AREA OF 1 FIN / AREF.
TANL      = TANGENT OF LEADING EDGE SWEEPBACK ANGEL
SWHA      = MID CHORD SWEEPBACK ANGLE - DEG.

SMALL=1.E-30
RAD=57.29578
AR=4.*BO/(CR*(1.+TR)+SMALL)
CT=CR*TR
AFAR=CR*BO*(1.+TR)/AREF/2.
TANL=(CR-CT)/(BO+SMALL)+TAN(SWTE/RAD)
SWLE=(ATAN(TANL))*57.3
TANH=TANL-.5*(CR-CT)/(BO+SMALL)
SWHA=(ATAN(TANH))*57.3
CBAR=1.0-(1.0-(2.0*TR**2)/(1.0+TR))/3.0
```
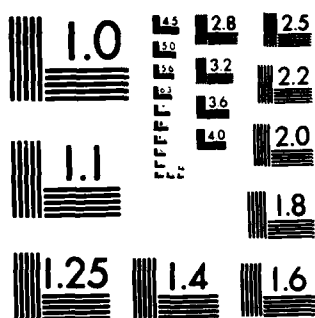
MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS-1963-A

```
YBAR=(((1.0+2.0*TR)/(1.0+TR))/3.0)
XM=YBAR*TANL*BU/(CR+SMALL)
CENT=XM+.5*CBAR
RETURN
END
SUBROUTINE STAN62(HEIGHT,VSOUND,RHO,PRESS,TEMP,IUNITS)

THIS SUBROUTINE IS A U. S. STANDARD MODEL ATMOSPHERE, 1962
PREPARED BY AMSMI-RST, 21 JULY 1967

THIS ROUTINE IS VALID BELOW 700,000 METERS
EXTRAPOLATION IS PROVIDED ABOVE 700,000 METERS

     1 HEIGHT    ALTITUDE                    M         FT
     2 VSOUND    VELOCITY OF SOUND           M/SEC     FT/SEC
     3 RHO       DENSITY                     KG/M3     SLUG/FT3
     4 PRESS     PRESSURE                    KG/M2     LBS/FT2
     5 TEMP      TEMPERATURE                 K         R
     6 IUNITS    =1 FOR METRIC
               =2 FOR ENGLISH

DIMENSION ZZ(13),PB(13),RL(13),ZB(13),TB(13),XXX(13)
DIMENSION HH(8),PBH(8),RLH(8),HBH(8),TBH(8)
DATA HH/ 11.0, 20.0, 32.0, 47.0, 52.0, 61.0, 79.0, 88.743/
DATA PBH/ 10331.9076, 2307.7398, 558.2615, 88.50965, 11.30876,
1  6.016163, 1.85682, .105812/
DATA RLH/ -6.5, 0.0, 1.0, 2.8, 0.0, -2.0, -4.0, 0.0/
DATA HBH/ 0.0, 11.0, 20.0, 32.0, 47.0, 52.0, 61.0, 79.0/
DATA TBH/ 288.15, 216.65, 216.65, 228.65, 270.65, 270.65, 252.65,
1  180.65/
DATA ZZ/ 100.,110.,120.,150.,160.,170.,190.,230.,300.,400.,500.,
1  600.,700./
DATA PB/ .016762, .0030667, .7499E-3, .2571E-3, .516E-4,
1  .3767E-4, .28476E-4, .17184E-4, .709767E-5, .1921E-5, .41097E-6,
2  .1117E-6, .3518E-7/
DATA RL/ 3.0, 5.0, 10.0, 20.0, 15.0, 10.0, 7.0, 5.0, 4.0, 3.3,
1  2.6, 1.7, 1.1/
DATA ZB/ 90.0, 100.0, 110.0, 120.0, 150.0, 160.0, 170.0, 190.0,
1  230.0, 300.0, 400.0, 500.0, 600.0/
DATA TB/ 180.65, 210.65, 260.65, 360.65, 960.65, 1110.65, 1210.65,
1  1350.65, 1550.65, 1830.65, 2160.65, 2420.65, 2590.65/
DATA XXX/ 33.166119, 33.064396, 32.96512, 32.784318, 32.530427,
1  32.455229, 32.309443, 32.016142, 31.492584, 30.704189,
1  29.808321, 28.937691, 28.123252/
DATA AA,BB,CC,DD,EE/
1     1.5731262E-7,2.4656553E-14,3.8667054E-21,6.0621354E-28,
2     9.5013649E-35/

***********************************          0 - 90,000.


IF (HEIGHT.LT.0.0001) HEIGHT=0.0
H = HEIGHT
IF(IUNITS .NE. 1)   H = H * .3048
Z=H*.001
IF(Z .GT. 90.0) GO TO 140
H = (H - AA*H**2 + BB*H**3 - CC*H**4 + DD*H**5 - EE*H**6) * .001

DO 550 I=1,8
IF(H - HH(I)) 551,551,550
550    CONTINUE
GO TO 140
551    IF((I.NE.2).AND.(I.NE.5).AND.(I.NE.8)) GO TO 120
```

96

```
110    TEMP=TBH(I)
PRESS=PBH(I)*EXP(-34.16479*(H-HBH(I))/TBH(I))
GO TO 130
120    TEMP=TBH(I) + (H-HBH(I))*RLH(I)
EP=34.16479/RLH(I)
PRESS=PBH(I)*(TBH(I)/TEMP)**EP
130 RHO = PRESS/(29.26945*TEMP)
VSOUND = 20.046333*TEMP**0.5
GO TO 460


*******************************          90,000. - 700,000.


140 Z1 = HEIGHT
IF(Z1 .GT. 170000.0) GO TO 142
Z BETWEEN 90000. M AND 170000. M
XM = (((((0.14186509E-27*Z1 -0.111458341E-21)*Z1
1  +0.359201410E-16) *Z1 -0.60665213E-11)*Z1
2  +0.565215163E-6) * Z1 -0.275300356E-1)*Z1
3  +5.76957191E+2
GO TO 150
Z GREATER THAN 170000. M
142 XM = ((((((1.180554E-33*Z1 -3.429162E-27)
1  *Z1+3.8159669E-21)*Z1 -2.0402054E-15)
2  *Z1 +5.6422141E-10)*Z1 -1.0700489E-4)
3  *Z1 +3.5629995E+1
150    DO 500 I=1,13
IF(Z-ZZ(I)) 450,450,500
500    CONTINUE
WRITE (6,290)
290 FORMAT(30H0 ALT .GT. 700000.0 M...STAN62)
I=13
450    TM=TB(I) + (Z-ZB(I))*RL(I)
TEMP=TM*XM/28.964
EP=XXX(I)/RL(I)
PRESS=PB(I)*(TB(I)/TM)**EP
RHO = PRESS/(29.26945*TM)
VSOUND = (401.90467 * TM) ** 0.5
460 IF(IUNITS .EQ. 1)    GO TO 999
VSOUND = VSOUND * 3.2808333
RHO = RHO * .194032E-2
PRESS = PRESS * .20482
TEMP = TEMP * 1.8
999 RETURN
END
SUBROUTINE BRIT (XM,AR,TR,SWEEP,CLA,XCPCB)
TAKEN FROM THE BRITISH DATA SHEETS  S.01.03.06
                                    S.01.03.05
                                    S.01.03.04
                                    S.01.03.03
                                    S.08.01.02
XM     = FREE STREAM MACH NO.
AR     = ASPECT RATIO (TWO WINGS JOINED WITHOUT BODY)
TR     = TAPER RATIO
SWEEP = WING MID-CHORD SWEEPBACK ANGLE (DEG)
CLA    = LIFT COEFF. SLOPE, BASED ON EXPOSED WING AREA  1/RAD.
XCPCB = CENTER OF PRESSURE (PERCENT MEAN GEOMETERIC CHORD),
    MEASURED FROM LEADING EDGE MEAN GEOMETERIC CHORD.
DIMENSION XT1(15),YT1(7),ZT1(4),XT2(8),YT2(5),ZT2(4),YT4(7)
DIMENSION BAR1(15,7,4), BAR2(8,5,4),BAR3(15,7,4),BAR4(8,7,4)
DATA XT1/0.,.5,1.,1.5,2.,2.5,3.,3.5,4.,4.5,5.,5.5,6.,6.5,7./
DATA YT1/0.,1.,2.,3.,4.,5.,6./
DATA ZT1/0.,.25,.5,1./
DATA XT2/0.,1.,2.,3.,4.,5.,6.,7./
```

97

```
DATA YT2/0.,1.,2.,3.,4./
DATA I14/0.,1.,2.,3.,4.,5.,6./
DATA ZT2/0.,.25,.5,1./
DATA (((BAR1(I,J,K),I=1,15),J=1,7),K=1,2) /
A                1.56,1.52,1.41,1.30,1.20,1.11,1.03,.95,.89,.83,
1.78,.74,.70,.66,.63,1.56,1.52,1.40,1.27,1.17,1.08,1.00,.93,.87,
2.82,.77,.73,.69,.65,.62,1.56,1.47,1.30,1.17,1.08,1.01,.95,.89,.84,
3.79,.75,.71,.67,.64,.61,1.20,1.21,1.13,1.05,.99,.93,.88,.83,.79,
4.75,.71,.68,.65,.62,.59,1.05,1.01,.98,.94,.89,.85,.81,.77,.73,.7,
5.67,.64,.61,.59,.57,.90,.88,.86,.83,.80,.77,.74,.71,.68,.66,.63,
6.61,.59,.57,.55,.79,.78,.77,.75,.73,.70,.68,.65,.63,.61,.59,.57,
7.55,.53,.52,1.57,1.53,1.45,1.34,1.25,1.16,1.07,1.,.93,.875,.82,.78
8.,.735,.695,.66,1.57,1.53,1.42,1.31,1.20,1.11,1.03,.97,.91,.86,.81,
9.765,.72,.685,.65,1.57,1.45,1.31,1.205,1.12,1.05,.98,.925,.87,.82,
1.78,.74,.70,.665,.63,1.26,1.19,1.12,1.06,1.00,.95,.90,.85,.81,.77,
2.74,.70,.67,.64,.61,1.05,1.00,.96,.92,.885,.86,.83,.79,.76,.725,
3.69,.665,.64,.61,.59,.90,.855,.82,.80,.78,.76,.74,.72,.70,.67,.64,
4.62,.60,.57,.55,.79,.75,.73,.71,.70,.68,.67,.65,.64,.62,.60,.58,
5.56,.55,.53/
DATA (((BAR1(I,J,K),I=1,15),J=1,7),K=3,4) /
A                1.58,1.53,1.45,1.35,1.25,1.16,1.07,1.00,.93,.88,
1.82,.78,.73,.69,.66,1.58,1.52,1.42,1.31,1.21,1.12,1.04,.98,.915,
2.86,.805,.76,.72,.68,.64,1.58,1.44,1.32,1.20,1.12,1.05,.98,.92,
3.87,.82,.78,.74,.70,.66,.63,1.26,1.20,1.13,1.06,1.01,.96,.90,.85,
4.81,.77,.74,.70,.66,.63,.60,1.05,1.01,
5                .97,.93,.89,.85,.82,.78,.75,.72,.68,.66,.63,
6.60,.58,.90,.87,.84,.81,.79,.76,.73,.71,.68,.66,.64,.62,.59,.57,
7.55,.79,.76,.74,.71,.69,.67,.66,.64,.62,.60,.59,.57,.55,.54,.52,
8 1.57,1.52,1.45,1.34,1.22,1.12,1.04,.97,.90,.84,.77,.74,.70,.67,
9.64,1.57,1.51,1.42,1.30,1.18,1.08,1.00,.94,.88,.82,.78,.73,.69,
1.65,.63,1.57,1.48,1.36,1.22,1.10,1.02,.95,.88,.82,.78,.73,.69,.66,
2.63,.61,1.27,1.17,1.10,1.025,.96,.91,.86,.81,.77,.73,.69,.66,.63,
3.60,.58,1.06,.99,.94,.89,.84,.81,.78,.74,.71,.68,.65,.62,.60,.58,
4.56,.91,.85,.80,.77,.74,.72,.70,.68,.65,.62,.60,.58,.56,.55,.54,
5.79,.74,.70,.67,.65,.63,.62,.61,.59,.58,.56,.54,.53,.52,.50/
DATA BAR2 /
A                .265,.270,.273,.275,.274,.273,.270,.268,.380,
1.347,.327,.314,.303,.295,.290,.285,.500,.420,.378,.352,.335,.325,
2.318,.313,.505,.445,.405,.380,.365,.353,.345,.340,.505,.460,.432,
3.410,.395,.383,.375,.370,.145,.195,.225,.240,.247,.250,.250,.250,
4.262,.265,.267,.267,.267,.267,.267,.267,.380,.332,.305,.290,.283,
5.282,.282,.282,.395,.355,.330,.315,.305,.298,.295,.293,.405,.385,
6.365,.345,.325,.315,.307,.303,.070,.185,.225,.237,.243,.245,.247,
7.248,.177,.217,.235,.243,.245,.245,.245,.244,.285,.247,.243,.247,
8.250,.250,.248,.247,.305,.267,.257,.255,.255,.255,.255,.255,.317,
9.287,.275,.270,.270,.270,.270,.270,0.,.175,.225,.237,.243,.245,
1.245,.245,.085,.110,.165,.205,.220,.225,.227,.230,.165,.167,.170,
1.182,.197,.205,.210,.213,.193,.190,.189,.190,.193,.197,
2                .200,.203,.200,.197,.189,.190,.193,.195,.196,.198/
DATA (((BAR3(I,J,K),I=1,15),J=1,7),K=1,2) /
A                1.56,1.70,1.76,1.75,1.70,1.43,1.22,1.06,.94,.85,
1.77,.71,.65,.60,.56,1.56,1.735,1.76,1.62,1.48,1.35,1.24,1.09,.96,
2.86,.78,.715,.66,.61,.565,1.56,1.535,1.47,1.395,1.31,1.22,1.14,
31.07,1.005,.90,.805,.73,.67,.62,.58,1.26,1.30,1.275,1.233,1.17,
41.11,1.05,1.00,.945,.90,.86,.775,.70,.645,.60,1.046,1.07,1.085,
51.085,1.06,1.023,.986,.95,.90,.86,.822,.79,.76,.682,.635,.895,
6.915,.93,.94,.94,.93,.91,.888,.855,.822,.788,.76,.73,.707,.682,
7.79,.795,.80,.80,.80,.802,.805,.81,.81,.78,.755,.73,.71,.68,.661,
81.57,1.56,1.85,1.82,1.64,1.41,1.21,1.06,.94,.845,.77,.71,.65,.60,
9.558,1.57,1.50,1.83,1.72,1.585,1.41,1.215,1.065,.955,.86,.78,.716,
1.66,.61,.562,1.57,1.13,1.46,1.46,1.40,1.305,1.22,1.11,.985,.89,
2.804,.73,.67,.62,.572,1.26,1.18,1.10,1.23,1.275,1.20,1.125,1.065,
31.015,.94,.85,.772,.71,.65,.60,1.05,1.05,1.05,1.05,1.05,1.05,1.04,
```
98

```
41.01,.962,.92,.87,.815,.74,.68,.63,.90,.908,.915,.923,.93,.942,
5.95,.935,.91,.875,.84,.815,.78,.73,.67,.79,.786,.78,.78,.779,.78,
6.785,.80,.82,.83,.82,.785,.755,.73,.704/
DATA (((BAR3(I,J,K),I=1,15),J=1,7),K=3,4) /
A                  1.58,1.88,1.92,1.80,1.59,1.36,1.17,1.03,.92,.84,
1.75,.69,.635,.59,.55,1.58,1.80,1.90,1.76,1.55,1.355,1.18,1.045,
2.935,.847,.77,.705,.645,.60,.56,1.58,1.46,1.35,1.445,1.43,1.32,
31.25,1.08,.97,.87,.79,.72,.66,.61,.57,1.26,1.25,1.235,1.22,1.26,
41.21,1.145,1.08,.995,.91,.83,.756,.693,.64,.59,1.05,1.05,1.055,
51.055,1.055,1.07,1.05,1.015,.97,.925,.86,.80,.74,.68,.63,.90,.90,
6.902,.903,.905,.907,.91,.91,.90,.88,.86,.83,.77,.71,.67,.79,.792,
7.80,.80,.804,.81,.813,.816,.82,.822,.817,.798,.76,.74,.69,1.57,
81.79,2.0,1.8,1.52,1.29,1.12,.985,.88,.795,.72,.665,.62,.575,.535,
91.57,1.60,2.0,1.72,1.48,1.29,1.13,1.0,.90,.81,.74,.68,.63,.583,
1.545,1.57,1.55,1.52,1.48,1.44,1.29,1.16,1.03,.93,.835,.76,.70,
2.645,.60,.56,1.27,1.30,1.30,1.28,1.24,1.19,1.145,1.05,.96,.87,.80,
3.735,.68,.625,.58,1.06,1.055,1.05,1.04,1.02,.995,.98,.97,.97,.90,
4.83,.765,.70,.655,.61,.905,.90,.885,.875,.865,.86,.858,.855,.853,
5.85,.84,.785,.735,.69,.65,.795,.783,.78,.77,.762,.76,.757,.75,.75,
6 .75,.758,.76,.77,.74,.72/
DATA BAR4 /        .250,.350,.450,.465,.475,.483,.486,.490,.380,
1.472,.472,.472,.480,.487,.490,.495,.5,.5,.5,.5,.5,.5,.501,.501,
2.505,.54,.54,.54,.54,.54,.525,.520,.505,.542,.580,.580,.580,.580,
3.580,.558,.509,.540,.585,.625,.625,.625,.625,.625,.515,.555,.595,
4.633,.673,.673,.673,.673,.145,.295,.450,.475,.485,.490,.495,.495,
5.267,.350,.437,.473,.483,.487,.492,.493,.380,.445,.445,.445,.488,
6.502,.502,.502,.395,.440,.481,.481,.481,.532,.530,.523,.405,.433,
7.470,.525,.525,.525,.570,.560,.413,.457,.503,.550,.570,.570,.570,
8.615,.425,.450,.477,.510,.560,.625,.625,.625,.070,.260,.450,.477,
9.485,.490,.493,.493,.177,.270,.365,.457,.475,.482,.485,.485,.285,
1.300,.385,.415,.480,.485,.485,.485,.305,.355,.400,.435,.465,.511,
2.510,.505,.317,.323,.326,.460,.487,.501,.543,.537,.330,.320,.310,
3.425,.505,.523,.550,.585,.337,.315,.300,.423,.500,.560,.580,.605,
40.00,.330,.445,.465,.475,.483,.485,.485,.085,.310,.400,.440,.455,
5.465,.470,.470,.165,.290,.380,.425,.448,.458,.467,.475,.193,.300,
6.390,.433,.457,.470,.477,.477,.200,.330,.423,.465,.485,.493,.496,
7.495,.200,.330,.423,.465,.485,.493,.496,.495,.200,.330,.423,.465,
8.485,.493,.496,.495/
X=AR*SQRT(ABS(1.-XM**2))
Y=AR*TAN(SWEEP/57.29578)
Z=TR
IF(X.GT.7.) WRITE (6,900) X
IF(Z.GT.1.) WRITE (6,902) Z
IF(XM.GT.1.0) GO TO 1
CALL TABLE3 (2,CLAR,BAR1,X,XT1,15,3,Y,YT1,7,3,Z,ZT1,4,3)
IF(Y.GT.4.) WRITE (6,901) Y
CALL TABLE3 (2,XCPCB,BAR2,X,XT2,8,3,Y,YT2,5,3,Z,ZT2,4,3)
CLA=CLAR*AR
RETURN
1      CALL TABLE3 (2,CLAR,BAR3,X,XT1,15,3,Y,YT1,7,3,Z,ZT1,4,3)
IF(Y.GT.6.) WRITE (6,901) Y
CALL TABLE3 (2,XCPCB,BAR4,X,XT2,8,3,Y,YT4,7,3,Z,ZT2,4,3)
CLA=CLAR*AR
RETURN
900    FORMAT (1X,'EXTRAPOLATION REQUIRED, '10HAR'BETA = F10.4)
901    FORMAT (1X,'EXTRAPOLATION REQUIRED, '11HAR'TANSW = F10.4)
902    FORMAT (1X,'EXTRAPOLATION REQUIRED, TAPER RATIO = 'F10.4)
END
SUBROUTINE MCDEVT (FMACH,AR,CLA)
FIN NORMAL FORCE FROM NACA REPT. 1253  (MCDEVITT)
RECTANGULAR ONLY
DIMENSION TFMACH(6),TAR(7),TCLA(7,6,1)
DATA (TFMACH(I), I=1,6) /.0,.5,.8,.9,1.,1.1/
```

```
      DATA (TAR(I), I=1,7) /.0,.5,1.,1.5,2.,3.,4./
      DATA ICLA /.0,.014,.029,.04,.049,.063,.075,
     + .0,.014,.029,.04,.049,.063,.075,.0,.014,.029,.041,.052,.067,.076,
     + .0,.016,.03,.043,.056,.081,.107,.0,.018,.034,.05,.064,.086,.099,
     + .0,.018,.034,.048,.06,.078,.089/
      CALL TABLE2 (2,CLA,ICLA,AR,TAR,7,2,FMACH,TFMACH,6,2)
      CLA=CLA*57.3
      RETURN
      END
      SUBROUTINE FACTOR (BOW,RBW,CRW,XHW,XLW,DELTW,BOT,RBT,TRT,XLT,XCPT,
     C ALPHA,XI,FWSW)
      DIMENSION TL(4)
      DETERMINATION OF TAIL INTERFERENCE FACTOR (I) BY STRIP THEORY
      AND SLENDER BODY THEORY  FROM NACA 1307 - APPENDIX B
      USE THIS IN EQUATION  (55)  TO CALCULATE
      LIFT ON TAIL SECTION DUE TO WING VORTICES
      WING VORTEX LATERAL POSITION IS SET AT  .7854 (SEE EQUATION 39)
      BOW     = EXPOSED SEMI-SPAN OF WING
      RBW     = RADIUS OF BODY AT WING
      CRW     = ROOT CHORD OF WING
      XHW     = DISTANCE FROM WING LEADING EDGE TO WING HINGE LINE
      XLW     = DISTANCE FROM NOSE OF BODY TO WING LEADING EDGE
      DELTW   = WING DELFECTION ANGLE (SEE PAGE 11) - DEG
      BOT     = EXPOSED SEMI-SPAN OF TAIL
      RBT     = RADIUS OF BODY AT TAIL
      TRT     = TAPER RATIO OF TAIL (CT/CR)
      XLT     = DISTANCE FROM NOSE OF BODY TO TAIL LEADING EDGE
      XCPT    = CENTER OF PRESSURE OF TAIL (MEASURED FROM LEADING EDGE OF
          ROOT CHORD)
      ALPHA   = ANGLE OF ATTACK - DEG
      XI      = TAIL INTERFERENCE FACTOR
      FWSW    = RATIO OF VORTEX LATERAL POSITION TO WING EXPOSED SEMI-SPAN
          (MEASURED FROM BODY SURFACE)
      FW      = SPANWISE LOCATION OF WING VORTEX (FROM BODY CENTERLINE)
      FT      = SPANWISE LOCATION OF WING VORTEX AT TAIL FIN STATION
      HT      = HEIGHT OF WING VORTEX ABOVE TAIL FIN STATION
      HT      = EQUATION 41, PAGE 13
      RAD=57.29578
      PI=3.14159
      HT=-(CRW-XHW)*SIN(DELTW/RAD)+(XLT+XCPT-XLW-CRW)*SIN(ALPHA/RAD)
      ROSW=RBW/(RBW+BOW)
      C1=1.-ROSW
      C2=1.+ROSW**2
      C3=1.-ROSW**2
      FWSW=((PI/4.)*C3-ROSW+(C2**2/(2.*C3))*ASIN(C3/C2))/(2.*C1)
      FW=FWSW*BOW + RBW
      FT=FW-RBW+RBT
      S=BOT+RBT
      RS=RBT/S
      HS=HT/S
      FS=FT/S
      IF((FS.EQ.1.).AND.(HS.EQ.0.)) FS=.99
      FS1=(FS*RS**2)/(FS**2 + HS**2)
      HS1=(HS*RS**2)/(FS**2 + HS**2)
      I=1
80    TL(I)=(((1.0-RS*TRT)-FS*(1.0-TRT))/(2.0*(1.0-RS)))
      TL(I)=TL(I)*ALOG((HS**2 + (FS-1.0)**2)/(HS**2 + (FS-RS)**2))
      TL(I)=TL(I)-(1.-TRT)
      IF(HS.EQ.0.0) GO TO 81
      TL(I)=TL(I)-((1.-TRT)/(1.-RS))*HS*(ATAN((FS-1.)/HS)
     1  -ATAN((FS-RS)/HS))
81    I=I + 1
      GO TO (82,82,83,84,85),I
```

100

```
82      FS=-FS
GO TO 80
83      FS=FSI
HS=HSI
GO TO 80
84      FS=-FSI
GO TO 80
85      X1=(2.0/(1.0 + TRT))*(TL(1)-TL(2)-TL(3)+TL(4))
RETURN
END
SUBROUTINE FNCROS (FMACH,AR,C1)
THIS SUBROUTINE CALCULATES THE COEFF. OF NON-LINEAR CONTRIBUTION
TO LIFT,  C1.
TAKEN FROM A PAPER PRESENTED AT THE SIXTH U. S. NAVAL SYMPOSUIM
ON AEROBALLISTICS, 1 NOV 1963.
AUTHOR,  A. F. LAMPROS

NOTE:  THIS THEORY IS VALID ONLY FOR SUBSONIC FLOW.
   (C1) IS REDUCED QUADRATICALLY WITH MACH NUMBER
   BEYOND MACH 1.0.  THIS IS AN ARBITRARY FIX TO SMOOTH
   THE TRANSITION INTO SUPERSONIC FLOW.

DIMENSION TC1(10),TAR1(10)
DATA (TC1(I),I=1,10)/9.8,8.95,6.65,5.3,4.45,3.75,3.3,2.55,2.,1.55/
DATA (TAR1(I), I=1,10) /.0,.5,1.,1.5,2.,2.5,3.,4.,5.,6./
CALL INTERP (2,1,C1,TC1,AR,TAR1,10,3,MIN,MAX)
C1=C1*.0001
IF (FMACH.GT.1.) C1=C1/FMACH**4
RETURN
END
SUBROUTINE VORTEX (BOW,RBW,CRW,XHW,XLW,DELTW,PHIW,AWAR,BOT,RBT,
1  TRT,XLT,XCPT,PHIT,ART,ALPHA,CLAW,CLAT,BKWB,SKWB,CLIV,FNSW)
THIS SUBROUTINE CALC. LIFT ON TAIL SECTION DUE TO WING VORTICES.
THE METHOD OUTLINED IN NACA 1307 IS USED.
APPENDIX  B  IS USED FOR THE TAIL INTERFERENCE FACTOR (I).
INDEPENDENT ROLL ANGLES OF WING AND TAIL ARE ALLOWED.
THE SUBROUTINE ACCOUNTS FOR ROLL ANGLES BY ADJUSTING THE GEOMETRY
AND TAKING COMPONENTS IN THE PITCH PLANE.
THE FINAL ANSWER (CLIV) IS VECTORED IN THE ANGLE OF ATTACK PLANE
(OR PITCH PLANE) REGARDLESS OF WING OR TAIL ROLL ANGLES.
BOW     = EXPOSED SEMI-SPAN OF WING
RBW     = RADIUS OF BODY AT WING
CRW     = ROOT CHORD OF WING
XHW     = DISTANCE FROM WING LEADING EDGE TO WING HINGE LINE
XLW     = DISTANCE FROM NOSE OF BODY TO WING LEADING EDGE
DELTW   = WING DELFECTION ANGLE (SEE PAGE 11) - DEG
PHIW    = ROLL ANGLE OF WING FROM VERTICAL (DEG).
AWAR    = RATIO OF WING AREA(TWO WINGS) TO REFERENCE AREA.
BOT     = EXPOSED SEMI-SPAN OF TAIL
RBT     = RADIUS OF BODY AT TAIL
TRT     = TAPER RATIO OF TAIL (CT/CR)
XLT     = DISTANCE FROM NOSE OF BODY TO TAIL LEADING EDGE
XCPT    = CENTER OF PRESSURE OF TAIL (MEASURED FROM LEADING EDGE OF
     ROOT CHORD)
PHIT    = ROLL ANGLE OF TAIL FROM VERTICAL (DEG).
ART     = ASPECT RATIO OF TAIL (TWO TAILS JOINED WITHOUT BODY).
ALPHA   = ANGLE OF ATTACK - DEG
CLAW    = LIFT COEFFICIENT SLOPE OF WING, BASED ON WING AREA (1/RAD)
CLAT    = LIFT COEFFICIENT SLOPE OF TAIL, BASED ON TAIL AREA (1/RAD)
BKWB    = UPWASH INTERFERENCE FACTOR FOR WING, DUE TO ALPHA.
SKWB    = UPWASH INTERFERENCE FACTOR FOR WING, DUE TO DELTW.
     SEE NACA 1307, PAGE 48, FOR  BKWB  AND  SKWB.
CLIV    = LIFT COEFFICIENT ON TAIL SECTION DUE TO WING VORTICES.
```

101

```
            BASED ON REFERENCE AREA.
            RETURN WITH  (CLTV)  SUMMED FOR ALL CASES.  (EACH WING
            AFFECTING EACH TAIL).
      X1    = TAIL INTERFERENCE FACTOR.  (ONE WING ACTING ON ONE TAIL)
      FWSW  = RATIO OF VORTEX LATERAL POSITION TO WING EXPOSED SEMI-SPAN
            (MEASURED FROM BODY SURFACE)
      DIMENSION PHWING(4),PHTAIL(4),HT(4),FT(4),PHIV(4),RV(4),IL(2)
      COMMENT......................................    NO. OF WING VORTEX AND TAILS
      PI=3.1415926536U
      RAD=57.295779512U
      IF(PHIW) 7,1,7
7         IF(PHIW-9U.) 2,1,2
1         NVORT=2
      PHWING(1)=PI/2.
      PHWING(2)=3.*PI/2.
      GO TO 3
2         NVORT=4
      PHWING(1)=PHIW/RAD
      PHWING(2)=(PHIW+9U.)/RAD
      PHWING(3)=(PHIW+18U.)/RAD
      PHWING(4)=(PHIW+27U.)/RAD
3         IF(PHIT) 8,4,8
8         IF(PHIT-9U.) 5,4,5
4         NTAIL=1
      PHTAIL(1)=PI/2.
      GO TO 6
5         NTAIL=2
      PHTAIL(1)=PHIT/RAD
      PHTAIL(2)=(PHIT+90.)/RAD
6         CONTINUE
      COMMENT.............................................    WING VORTEX POSITION
      ROSW=RBW/(RBW+BOW)
      C1=1.-ROSW
      C2=1.+ROSW**2
      C3=1.-ROSW**2
      FWSW=((PI/4.)*C3-ROSW+(C2**2/(2.*C3))*ASIN(C3/C2))/(2.*C1)
      FW=FWSW*BOW+RBW
      FW=FW-RBW+RBT
      S=BOT+RBT
      RS=RBT/S
      DO 10 K=1,NVORT
      SIPHW=SIN(PHWING(K))
      COPHW=COS(PHWING(K))
      SIDLW=SIN(DELTW/RAD)
      SIALP=SIN(ALPHA/RAD)
      HT(K)=-(CRW-XHW)*SIDLW*ABS(SIPHW)
     C      +FW*COPHW+(XLT+XCPT-XLW-CRW)*SIALP
      FT(K)=FW*SIPHW+(CRW-XHW)*SIDLW*COPHW*SIPHW/ABS(SIPHW)
      PHI=ATAN(HT(K)/FT(K))
      PHIV(K)=PI/2.-PHI
      IF(FT(K)) 9,9,10
9         PHIV(K)=3.*PI/2.-PHI
10        RV(K)=SORT(FT(K)**2 + HT(K)**2)
      COMMENT..................................    CALC. TAIL INTERFER. FACTOR
      CLTV=0.0
      DO 15 L=1,2
      DO 11 J=1,NTAIL
      DO 11 K=1,NVORT
      F=RV(K)*COS(PHTAIL(J)-PHIV(K))
      H=RV(K)*SIN(PHTAIL(J)-PHIV(K))
      FS=F/S
      HS=H/S
      FSI=(FS*RS**2)/(FS**2 + HS**2)
```

```
HSI=(HS*HS**2)/(FS**2 + HS**2)
DO 12 I=1,2
TL(1)=(((1.0-RS*TRT)-FS*(1.0-TRT))/(2.0*(1.0-RS)))
TL(1)=TL(1)*ALOG((HS**2 + (FS-1.0)**2)/(HS**2 + (FS-RS)**2))
TL(1)=TL(1)-((1.0-TRT)/(1.0-RS))*((1.0-RS) + HS*(ATAN((FS-1.0)/HS)
C  -ATAN((FS-RS)/HS)))
FS=FSI
12    HS=HSI
XL    =TL(1)
XLIM  =TL(2)
XI=(2./(1.+TRT))*(XL-XLIM)*SIN(PHWING(K))/ABS(SIN(PHWING(K)))
OMMENT.............................    CALCULATE  CLTv
GAMUSV=(BKWB*(ALPHA/RAD )*ABS(SIN(PHWING(K)))+SKWB*DELTW/RAD )
C  *CLA*AWAR*ABS(SIN(PHWING(K)))/(4.*FWSW*BOW)
CLPART=XI*CLAT*ABS(SIN(PHTAIL(J)))          *BUT*GAMUSV/(PI*ART)
CLTv=CLTv+CLPART
11    CONTINUE
DO 13 J=1,NTAIL
13    PHTAIL(J)=PI-PHTAIL(J)
DO 14 K=1,NVORT
PHWING(K)=2.*PI-PHWING(K)
14    PHIV(K)=2.*PI-PHIV(K)
15    CONTINUE
RETURN
END
SUBROUTINE INTSLB (N,FMACH,BETA, BM,RB,CR,TR,BO,AR,CLA,
1 BKWB,BKBW,SKWB,SKBW)
WING-BODY AND TAIL-BODY INTERFERENCE FACTORS FROM CHARTS 1,4,5
NACA 1307
N    = 1     AFTERBODY
N    = 2     NO AFTERBODY
FMACH = FREE STREAM MACH NUMBER
BETA = SUBSONIC ON SUPERSONIC BETA
BM   = BETA * COTANGENT OF LEADING-EDGE SWEEP ANGLE
RB   = RADIUS OF BODY
CR   = ROOT CHORD
TR   = TAPER RATIO (CT/CR)
BO   = EXPOSED SEMI-SPAN
AR   = EXPOSED ASPECT RATIO
CLA  = LIFT COEFFICIENT SLOPE (PER RADIAN) - BASED ON WING OR
     TAIL EXPOSED AREA (2 PANELS)
BKWB = BIG (K) WING-BODY INTERFERENCE (CHART 1)
BKBW = BIG (K) BODY-WING INTERFERENCE (CHARTS 1, 4, 5)
SKWB = SMALL (K) WING-BODY INTERFERENCE (CHART 1)
SKBW = SMALL (K) BODY-WING INTERFERENCE (CHART 1)
DIMENSION TBKWB(11),TBKBW(11),TSKWB(11),TSKBW(11),TROS(11),
1 TBRC(7),TBRCN(7),TBM(18),TBMN(8),TKBWC(7,18),TKBWCN(7,8)
DATA (TBKWB(I), I=1,11)/
X 1.0,1.08,1.165,1.255,1.352,1.45,1.555,1.663,1.772,1.885,2.0/
DATA (TBKBW(I), I=1,11)/
X 0.0,0.13,0.28,0.44,0.61,0.80,1.0,1.22,1.45,1.70,2.0/
DATA (TSKWB(I), I=1,11)/
X 1.0,.963,.943,.935,.935,.938,.946,.958,.970,.985,1.0/
DATA (TSKBW(I), I=1,11)/
X 0.0,0.11,0.21,0.315,0.415,0.515,0.61,0.705,0.802,0.90,1.0/
DATA (TROS(I), I=1,11)/
X 0.0,0.1,0.2,0.3,0.4,0.5,0.6,0.7,0.8,0.9,1.0/
DATA (TBRC(I), I=1,7)/ .1,.6,1.0,1.4,2.0,2.8,4.0/
DATA (TBRCN(I), I=1,7)/ .2,.6,1.0,1.4,2.2,2.8,4.0/
DATA (TBM(I), I=1,18)/ .1,.2,.3,.4,.5,.6,.7,.8,.9,
X 1.0,1.2,1.6,2.0,3.0,4.0,7.0,10.0,99.9999E+30/
DATA (TBMN(I), I=1,8)/ .2,.4,.6,.8,1.0,2.0,4.0,99.9999E+30/
DATA TKBWC/
```

103

```
X .6331, .3498, .2665, .2332, .2332, .1832, .1333,
X 1.25, .8163, .6664, .5998, .4989, .4332, .3998,
X 1.866, 1.25, 1.05, .933, .8163, .6831, .6331,
X 2.332, 1.666, 1.399, 1.25, 1.0099, .9496, .8497,
X 2.849, 2.016, 1.749, 1.549, 1.366, 1.199, 1.05,
X 3.249, 2.316, 2.016, 1.816, 1.633, 1.466, 1.233,
X 3.615, 2.632, 2.266, 2.066, 1.893, 1.633, 1.433,
X 3.898, 2.882, 2.499, 2.266, 2.0, 1.799, 1.566,
X 4.215, 3.149, 2.716, 2.466, 2.199, 1.966, 1.733,
X 4.415, 3.315, 2.882, 2.599, 2.332, 2.083, 1.832,
X 4.781, 3.615, 3.149, 2.866, 2.516, 2.249, 2.016,
X 5.181, 3.998, 3.515, 3.215, 2.849, 2.516, 2.232,
X 5.515, 4.248, 3.749, 3.432, 3.082, 2.732, 2.382,
X 5.914, 4.665, 4.132, 3.798, 3.399, 3.049, 2.682,
X 6.214, 4.915, 4.382, 4.015, 3.632, 3.232, 2.866,
X 6.647, 5.265, 4.681, 4.315, 3.898, 3.499, 3.082,
X 6.864, 5.431, 4.848, 4.465, 4.048, 3.632, 3.215,
X 7.23, 5.848, 5.231, 4.831, 4.365, 3.932, 3.482/
DATA TKBWCN/
X .9653, .5442, .3685, .2632, .1755, .1229, .0877,
X 1.86, 1.14, .737, .526, .333, .246, .176,
X 2.597, 1.509, 1.017, .737,.456, .351, .281,
X 3.123, 1.772, 1.176, .84, .544, .439, .316,
X 3.65, 2.264, 1.457, 1.053, .684, .544, .366,
X 4.56, 2.861, 1.842, 1.316, .842, .666, .491,
X 5.247, 3.287, 2.088, 1.527, 1.000, .789, .544,
X 6.107, 3.879, 2.51, 1.772, 1.193, .912, .649/
ROS=RB/(RB + BO)
IF(FMACH.LE.1.0) GO TO 1
IF(BM.GT.99.9999E+30) BM=99.9999E+30
CON=BETA*AR*(1.0 + TR)*(1.0 + 1.0/ BM)
IF(CON.LE.4.0) GO TO 1
BRC=2.0*BETA*RB/CR
IF(BRC.GT.4.0) BRC=4.0
CON2=BETA*CLA*(TR + 1.0)*(1.0/ROS - 1.0)
IF(N.GT.1) GO TO 3
CALL TABLE2 (2,ANR,TKBWC,BRC,TBRC,7,3,BM,TBM,18,3)
BKBW=ANR/CON2
GO TO 4
3      CALL TABLE2 (2,ANR,TKBWCN,BRC,TBRCN,7,3,BM,TBMN,8,3)
BKBW=ANR/CON2
GO TO 4
1      CALL INTERP (2,1,BKBW,TBKBW,ROS,TROS,11,3,MIN,MAX)
4      CALL INTERP (2,1,BKWB,TBKWB,ROS,TROS,11,3,MIN,MAX)
CALL INTERP (2,1,SKBW,TSKBW,ROS,TROS,11,3,MIN,MAX)
CALL INTERP (2,1,SKWB,TSKWB,ROS,TROS,11,3,MIN,MAX)
RETURN
END
SUBROUTINE INTERP (IXTRP,LMT,Y,YT,X,XT,NX,NPX,MINX,MAXX)


TABLE LOOK-UP ROUTINE FOR 1 INDEPENDENT VARIABLE
WITH SIMPLE INTERPOLATION OR EXTRAPOLATION.

IXTRP = 1 EXTRAPOLATE IF NECESSARY.
IXTRP = 2 EXTRAPOLATION NOT ALLOWED. TAKE THE LAST(OR FIRST) POINT.
LMT = 1 PROGRAM WILL DETERMINE SUBSCRIPT RANGE (MINX TO MAXX).
LMT = 2 PROGRAM ASSUMS THAT MINX AND MAXX SUBSCIPTS ARE KNOWN.
Y         ANSWER OR DEPENDENT VARIABLE CORRESPONDING TO INPUT (X).
YT        TABLE OF DEPENDENT VARIABLES CORRESPONDING TO XT.
X         ARGUMENT OR INDEPENDENT VARIABLE FOR WHICH ANSWER (Y) WILL
     BE DETERMINED.
XT        TABLE OF INDEPENDENT VARIABLES.
NX        NUMBER OF POINTS IN XT,YT
```

104

```
NPX       NUMBER OF POINTS TO BE USED FOR INTERPOLATION.
MINX      MINIMUM XT SUBSCRIPT USED FOR INTERPOLATION.
MAXX      MAXIMUM XT SUBSCRIPT USED FOR INTERPOLATION.

      DIMENSION XT(NX),YT(NX)
      IF (IXTRP.EQ.1) GO TO 140
      Y=YT(1)
      IF(X.LE.XT(1)) RETURN
      Y=YT(NX)
      IF(X.GE.XT(NX)) RETURN
140   IF(LMT.EQ.2) GO TO 130
      CALL LIMIT (X,XT,NX,NPX,MINX,MAXX)
130   Y=YT(MINX)
      IF(MINX.EQ.MAXX) RETURN
      Y=0.
      DO 120 J=MINX,MAXX
      P=1.
      DO 110 I=MINX,MAXX
      IF(I.EQ.J) GO TO 110
      P=P*(X-XT(I))/(XT(J)-XT(I))
110   CONTINUE
120   Y=Y + YT(J)*P
      RETURN
      END
      SUBROUTINE TABLE2 (IXTRP,W,WT,X,XT,NX,NPX,Y,YT,NY,NPY)

      TABLE LOOK-UP ROUTINE FOR 2 INDEPENDENT VARIABLES.
      IXTRP = 1 EXTRAPOLATE IF NECESSARY.
      IXTRP = 2 EXTRAPOLATION NOT ALLOWED. TAKE THE LAST(OR FIRST) POINT.
      W       = ANSWER,(DEPENDENT VARIABLE CORRESPONDING TO INPUTS  X,Y)
      WT      = TABLE OF DEPENDENT VARIBALE CORRESPONDING TO XT,YT
         WT(I,J)    INCREMENT SUBSCRIPTS LEFT TO RIGHT WHEN LOADING
      X       = THE ARGUMENT OR INDEPENDENT VARIABLE  X
      XT      = TABLE OF INDEP.  X  VALUES (MUST BE IN INCREASING ORDER)
      NX      = NUMBER OF POINTS IN  XT
      NPX     = NUMBER OF POINTS TO USE FOR  X  INTERPOLATION
      Y       = THE ARGUMENT OR INDEPENDENT VARIABLE  Y
      YT      = TABLE OF INDEP.  Y  VALUES (MUST BE IN INCREASING ORDER)
      NY      = NUMBER OF POINTS IN  YT
      NPY     = NUMBER OF POINTS TO USE FOR  Y  INTERPOLATION

      DIMENSION XT(NX),YT(NY),WT(NX,NY), B(20)
      CALL LIMIT (Y,YT,NY,NPY,MINY,MAXY)
      CALL LIMIT (X,XT,NX,NPX,MINX,MAXX)
      DO 42 J=MINY,MAXY
      CALL INTERP (IXTRP,2,B(J),WT(1,J),X,XT,NX,NPX,MINX,MAXX)
42    CONTINUE
      CALL INTERP (IXTRP,2,W,B,Y,YT,NY,NPY,MINY,MAXY)
      RETURN
      END
      SUBROUTINE TABLE3 (IXTRP,W,WT,X,XT,NX,NPX,Y,YT,NY,NPY,Z,ZT,NZ,NPZ)

      TABLE LOOK-UP ROUTINE FOR 3 INDEPENDENT VARIABLES.
      IXTRP = 1 EXTRAPOLATE IF NECESSARY.
      IXTRP = 2 EXTRAPOLATION NOT ALLOWED. TAKE THE LAST(OR FIRST) POINT.
      W       = ANSWER,(DEPENDENT VARIABLE CORRESPONDING TO INPUTS  X,Y,Z)
      WT      = TABLE OF DEPENDENT VARIBALE CORRESPONDING TO XT,YT,ZT
         WT(I,J,K)  INCREMENT SUBSCRIPTS LEFT TO RIGHT WHEN LOADING
      X       = THE ARGUMENT OR INDEPENDENT VARIABLE  X
      XT      = TABLE OF INDEP   X  VALUES (MUST BE IN INCREASING ORDER)
      NX      = NUMBER OF POINTS IN  XT
      NPX     = NUMBER OF POINTS TO USE FOR  X  INTERPOLATION
      Y       = THE ARGUMENT OR INDEPENDENT VARIABLE  Y
```

105

```
YT      = TABLE OF INDEP.  Y  VALUES (MUST BE IN INCREASING ORDER)
NY      = NUMBER OF POINTS IN  YT
NPY     = NUMBER OF POINTS TO USE FOR  Y  INTERPOLATION
Z       = THE ARGUMENT OR INDEPENDENT VARIABLE  Z
ZT      = TABLE OF INDEP.  Z  VALUES (MUST BE IN INCREASING ORDER)
NZ      = NUMBER OF POINTS IN  ZT
NPZ     = NUMBER OF POINTS TO USE FOR  Z  INTERPOLATION

      DIMENSION XT(NX),YT(NY),ZT(NZ),WT(NX,NY,NZ), B(20),A(10)
      CALL LIMIT (Z,ZT,NZ,NPZ,MINZ,MAXZ)
      CALL LIMIT (Y,YT,NY,NPY,MINY,MAXY)
      CALL LIMIT (X,XT,NX,NPX,MINX,MAXX)
      DO 41 K=MINZ,MAXZ
      DO 42 J=MINY,MAXY
      CALL INTERP (IXTRP,2,B(J),WT(1,J,K),X,XT,NX,NPX,MINX,MAXX)
42    CONTINUE
      CALL INTERP (IXTRP,2,A(K),B,Y,YT,NY,NPY,MINY,MAXY)
41    CONTINUE
      CALL INTERP (IXTRP,2,W,A,Z,ZT,NZ,NPZ,MINZ,MAXZ)
      RETURN
      END
      SUBROUTINE LIMIT (X,XT,NX,NP ,MINX,MAXX)
      THIS SUBROUTINE WILL FIND THE MINIMUM AND MAXIMUM SUBSCRIPTS
      (OR RANGE) TO BE CONSIDERED FOR INTERPOLATION.
      DIMENSION XT(NX)
      NPX=NP
      IF(NPX.GT.NX) NPX=NX
      DO 25 I=1,NX
      IF(XT(I)-X) 25,22,21
25    CONTINUE
............................... GREATER THAN MAX SUBSCRIPT
24    MAXX=NX
      MINX=NX-NPX+1
      RETURN
............................... WITHIN RANGE
21    MINX=I-NPX/2
      MAXX=MINX+NPX-1
      IF(MAXX.GT.NX) GO TO 24
      IF(MINX.GE.1) RETURN
............................... LESS THAN MIN SUBSCRIPT
      MINX=1
      MAXX=NPX
      RETURN
............................... NO INTERP NECESSARY
22    MINX=I
      MAXX=I
      RETURN
      END
$$END
```

106

DISTRIBUTION

	No. of Copies
Commander US Army Picatinny Arsenal ATTN: SMUPA-VC3, Mr. A. Loeb Dover, NJ 07801	1
Commander Research Laboratories ATTN: SMUEA-RA, Mr. A. Flatau Edgewood Arsenal, MD 21010	1
Commander Air Force Armament Laboratory ATTN: Mr. C. Butler Mr. Winchenbach Eglin AFB, FL 32542	1 1
Air Force Flight Dynamics Laboratory ATTN: FDMM, Mr. G. Fleeman Wright-Patterson AFB, OH 45433	1
Commander US Army Armament R&D Command ATTN: DRDAR-BLL, Dr. C. Murphy -BLL-FT, Mr. Chase Aberdeen Proving Ground, MD 21005	1 1
Commander US Naval Surface Weapons Center ATTN: Mr. S. Hastings Mr. R. T. Hall Library White Oak Silver Spring, MD 20910	1 1 1
Commanding Officer and Director Naval Ship R&D Center ATTN: Aerodynamic Laboratory Carderock, MD 20007	1
Naval Weapons Center ATTN: Mr. R. Meeker China Lake, CA 93555	1
NASA-Ames Research Center ATTN: Technical Library Moffett Field, CA 94035	1

No. of
Copies

NASA-Langley Research Center
ATTN: Mr. L. Spearman   1
Mr. C. Jackson   1
Technical Library   1
Langley Field, VA 23365

NASA-Lewis Research Center
ATTN: Technical Library   1
Cleveland, OH 44135

NASA-Marshall Space Flight Center
ATTN: Mr. H. Struck   1
Technical Library   1
Marshall Space Flight Center, AL 35812

US Air Force Academy
ATTN: Lt. Col. W. A. Edgington
DFAN   1
USAF Academy, CO 80840

IIT Research Institute
ATTN: GACIAC   1
10 West 35th Street
Chicago, IL 60616

US Army Materiel Systems Analysis Activity
ATTN: DRXSY-MP   1
Aberdeen Proving Ground, MD 21005

DRSMI-R   1
DRSMI-RD   1
-RDK, Mr. Deep   1
Mr. Sanders   15
-RLA, Dr. Richardson   1
-RPR   15
-RPT (Record Copy)   1
DRSMI-LP, Mr. Voigt   1

ATE
ME